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SCIENCE AND THE DAILY PRESS.

IN a letter to us, dated June 3rd, a friend adds in a postscript: "Did you notice in to-days *Times* the mention of Herz's micro-telephone?" We assure our correspondent that we did, and that at the time we mentally resolved to bring the subject once again before our readers. Only a month has elapsed since we described this so-called invention of Dr. Herz, and we then gave our opinion upon the merits of the apparatus, such as it possesses, in pretty plain terms, which are doubtless fresh in the memory of those who happened to peruse our comments. We have often wondered who upon earth acts, especially with regard to electrical subjects, as the scientific representative of the *Times*. Without doubt he is, like Ally Sloper, an "Eminent One," but that does not constitute him even an amateur electrician.

The gentleman who "does" electricity for the leading daily ought to have a distinctive title, and we cannot at the moment think of a better one with which to dub him than "Rhapsodist." But it is necessary to remark that in interpreting this expression the reader must not confound him who recites or sings rhapsodies, and whose real profession in ancient days was to recite the verses of Homer and other poets, with the man who has a confused, incoherent, and excited style of writing. It is to the latter class of being that the "Rhapsodist" of the *Times* belongs, and he possesses the additional failing that the subject upon which he discourses is entirely beyond his conception. The *Times* is a powerful organ, and it appeals to the highest and best in the land in point of culture and position. All the more reason, then, that the writers attached to its staff should be capable of clearly understanding and forming a correct judgment upon any invention with which it is intended to appeal to the public. On many occasions we have thought it necessary to protest against the fallacious and misleading statements which so frequently disfigure the columns of the daily press.

What attitude should a journal devoted to technical subjects, and with the earnest desire of giving the most reliable information, adopt towards another whose articles are calculated to misinform a certain section of the public? The consensus of opinion would probably decide that it should be treated with contemptuous silence. There are periods, however, when one feels compelled to depart from this golden rule, and the present occasion is one of them, for when a paper holds such a high position that vast influence is attached to its articles, it is high time to protest against rhapsodical utterances of the kind devoted to the micro-telephone of Dr. Herz. The manner in which the names of Sir Charles Bright and Mr. Preece are associated with the subject is calculated to produce a false impression upon the mind of the casual reader, although in reality these gentlemen speak of it only as a practical invention. The speaking tube is a practical invention, so is the mechanical telephone, and either would serve the main purposes claimed in the *Times* article on behalf of the micro-telephone, which may be summed up as recommending it for its admirable adaptability to the purposes of a household. For certain uses, which are of limited extent, the Herz apparatus may meet with employment, and we sincerely hope this will prove the case, for we naturally desire to see the extended use of electrical apparatus in all directions; but the *Times*, in the exuberance of its verbosity, goes too far, for the glowing terms applied to the micro-telephone irresistibly remind us that once we were promised stored electrical energy which should be delivered at our houses with the morning's milk. A little more practical acquaintance with electrical apparatus, a knowledge of what has been before accomplished by other inventors, better judgment, and a less vivid imagination: all these would be invaluable to the "Rhapsodist" of the *Times*. Naturally, no one acquainted with the subject under discussion would attach any importance to that gentleman's opinion; but the unfortunate part of the matter is that but an insignificantly small proportion of his readers are acquainted with electrical science in all its wide-spreading branches.

PRACTICAL ELECTRICAL MEASUREMENT.

By J. SWINBURNE.

(*Continued from page* 515.)

Gravity Instruments (*continued*).—It will be seen that in Mr. Evershed's instrument the scale can be made almost as desired by filing the fixed iron pieces to the right curves. Thus a voltmeter may be made to read over a large portion of its scale between, say, 45 and 55 volts while an ammeter can be made to read through a long range and give readable deflections throughout.

In the ammeters, from 200 ampère turns at the lowest reading to 700 at the highest are found to give very small differences in rising and falling over the whole scale. In the voltmeters, only 100 to 300 ampère turns are used so as to get high resistance. Thus a voltmeter for 100 volts measures at least 1,000 ohms. A key is used to avoid persistent magnetism errors. Fig. 12 is a view of one of these instruments.

Messrs. Paterson and Cooper make a gravity ammeter which consists of a single bar of copper passing behind a permanently magnetised needle whose deflection is resisted by the force of gravity.

Spring Instruments.—The Siemens dynamometer is too well known to need any lengthy description. In it there are two coils, one fixed and the other movable, being suspended vertically. In its normal position this is at right angles to the fixed coils, and when there is a current in both coils they tend to set themselves in the same plane. This tendency is resisted by a spiral spring which is tightened by turning a milled head until the movable coil is in its normal position, the force due to the current being exactly balanced by that

of the spring. The angle the top of the spring has been turned through can be read off, as there is a pointer attached to the milled head to which the top of the spring is fixed. The force tending to turn the suspended coil varies as the square of the current, and the force of the spring varies directly as the angle it is turned through; the current is therefore proportional to the square root of the angle the milled head is turned through. Electrical connection with the coil is made by means of mercury cups. If the instrument is a voltmeter both coils are made of fine wire; if an ammeter thicker wire is used. The ammeters have generally two fixed coils made with different numbers of turns, so that a larger range is obtained. These instruments are graduated in degrees, and a table of reference is given. This is a bad arrangement. It would be much better to mark the instruments in volts or ampères directly. At present it is very tedious working with these instruments. It takes some time to adjust the spring so as to bring the coil back exactly to zero, especially as the instruments are anything but dead beat, and if one has then to refer to the table to find out what the reading means, the waste of time becomes serious. A great deal has been said against the permanence of springs. The prejudice seems to be really undeserved. A bad spring does grow weaker in time, but if a good one is used to start with it is practically permanent. Kohlrausch has recently made some exhaustive experiments on this subject, and has found that good springs may be implicitly relied on for all ordinary purposes. The Siemens dynamometer has the advantage that it follows a simple law with accuracy, so that it is easy to check the instrument, as it need be calibrated at only one part of its scale, the rest of the readings being calculated. The spring can therefore be easily tested now and again. The writer found one Siemens dynamometer, which was carefully recalibrated, alter about 1 per cent. per month. This was not a new instrument. Either the original calibration was wrong or the spring had weakened considerably since the instrument was sent out. A Siemens dynamometer is easy to make, but great care should be taken to select springs that can be relied on. These instruments should also be provided with commutators, if they are required for use near dynamo machines. As the reading is the same whichever way the current goes, all that is wanted is to commute the current and take a second reading. A Siemens dynamometer is thus free from many of the common errors. If a spring is good it is practically free from change due to age. By means of a commutator it can be freed from error due to external fields; it reads the same with a rising as with a falling current; the coils are well ventilated, and the instrument does not necessarily need much power to work it, so that the coils need not get hot, and finally, if wrong, it can be calibrated again.

Professors Ayrton and Perry's long range spring instrument is most ingenious. It consists of a coil of wire, in the centre of which is a small tubular core of soft iron, in such a position that it is attracted into the solenoid when there is a current. This motion is resisted by a spring of a peculiar form. It is made of a long narrow strip of hard phosphor bronze rolled round a small mandrel so as to make a spring a few inches in length. The bottom of the spring is fixed to the low end of the tube inside it, while the top is fixed to a nut attached to the glass over the dial. The tube reaches a little above the dial, and the index is fastened to the top of it. When the core is attracted down into the solenoid the spring uncoils, thus turning the tube, and with it the index. The spring is so made that a very small movement of the tube produces a deflection of some 200 degrees. By this exceedingly pretty device a very simple long range instrument is obtained. The dial is horizontal, and has a mirror to avoid errors in reading which might otherwise occur, as the index is necessarily some little distance from the scale. The soft iron tube is made as thin as possible so that it may be saturated easily. This is important, as the more the iron is saturated the less is the persistent magnetism error. The writer is told that the error due to persistent magnetism is too small to matter throughout most of the scale, through it is 1 per cent. or so at the beginning. This instrument is free from many errors. It is very portable, and it does not need recalibration if good springs are used. Professor Ayrton has carefully checked an instrument from time to time during the last two years, and finds that if there is any weakening of the spring, it is so slight as to be imperceptible, being so small that it is insignificant in comparison even with the small errors that are unavoidable in calibration. The earlier voltmeters were shielded, that is to say, the solenoids themselves were placed inside a tube of soft iron. This arrangement is now abandoned. The iron is itself

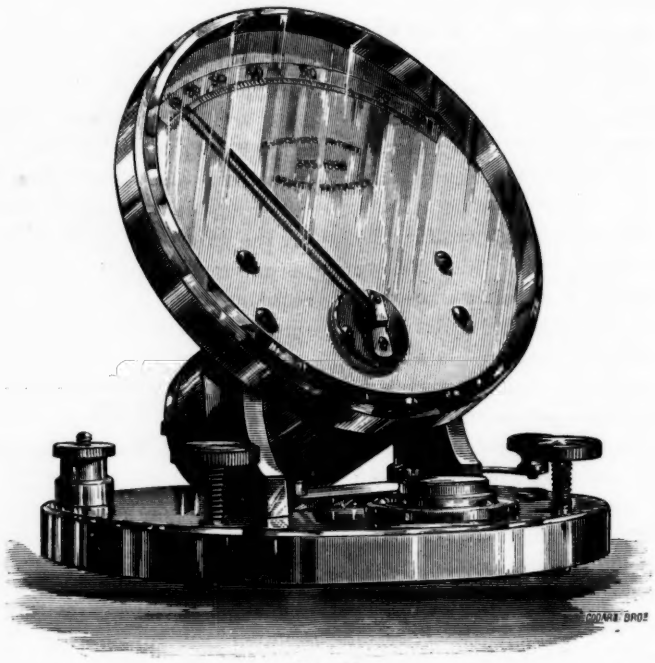

FIG. 12.

magnetised by the solenoid, and as it is only slightly magnetised, it causes persistent magnetism error. It is unnecessary to shade it, as the instrument is not perceptibly influenced by external fields, as the core moves bodily, while an external field merely tends to turn the core round like a compass needle. These instruments may therefore be used quite close to a dynamo if desired.

The scales are printed, and the instruments are made to fit the scales by adjusting a subsidiary movable coil till they read correctly. The scale is divided up into equal divisions. In discussing the Ayrton and Perry ohmmeter, it was pointed out that it is generally impossible to make an instrument follow the proportional law accurately; and it is a pity that these instruments are not calibrated carefully throughout the scale. In practice the adjustable coil is moved till the readings are right at two points about quarter or three-quarters of the full reading, so that the average error is small. The writer has the scale of an Ayrton and Perry instrument before him, which has been carefully calibrated throughout. At 10 ampères, which is the lowest reading, it is right, and it is also right at 50 ampères, which is the highest, but between these readings the new and old figures do not correspond at all. Thus 25 ampères read 27, which is an error of no less than 8 per cent. The curve of the attraction of a core into a solenoid can never become a straight line, but this can be to a certain extent corrected by putting the core in such a position that when it is drawn into the solenoid it moves into a position where the force is lessened.

The scales of Profs. Ayrton and Perry's instruments are here criticised somewhat exactingly, because the instruments are so good otherwise, and so very largely used, that such a fault is a matter of considerable importance. Probably others of the instruments already described are very much more incorrect than that whose scale has just been mentioned, as some makers do not seem to take the least trouble to calibrate correctly, but the writer could not order a collection of the latest instruments by different makers to test their calibration.

In Cunynghame's volt and ammeters an electro-magnet acts on a soft iron core so as to turn it. The core is mounted on a vertical arbor, to which a pointer is attached. The turning force due to the electro-magnet is opposed by a spring, which is turned till the pointer on the arbor comes to zero. This spring is operated by a milled head with an index, as in the Siemens dynamometer, but the scale is graduated directly in volts or ampères, as the case may be. The force measured is great, so that any error due to friction is small, and the field due to the electro-magnet is strong, so that external fields produce no perceptible errors. The persistent magnetism error must be great, as the cores of the magnet are large; so that care should be taken not to read with a gradually falling current. The error due to angular persistent magnetism is probably small, as the core cannot turn much, being held by stops. Messrs. Woodhouse and Rawson manufacture these instruments.

(*To be continued.*)

SIR WILLIAM THOMSON'S NEW ELECTRIC MEASURING INSTRUMENTS.

STANDARD ELECTRIC BALANCES.

1. These instruments are founded on the mutual forces, discovered by Ampère, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part will be called for brevity, an ampère ring, or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

2. In the balance instruments each movable ring is actuated by two fixed rings—all three approximately horizontal. In each of the balance instruments there are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm, pulled, one of them up and the other down, by a pair of fixed rings in its neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the direct-reading voltmeter there is only one fixed ring acting on a single movable ring, which is attached to one end of the balance arm and counterpoised by a weight at the other end.

3. In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

4. In the balance instruments the mid-range position of each movable ring is in the horizontal plane midway or nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other.

5. In the balances to measure direct currents of from 5 ampères to 1,000 ampères (see fig. 1) the outer diameter of each pair of fixed rings is somewhat smaller

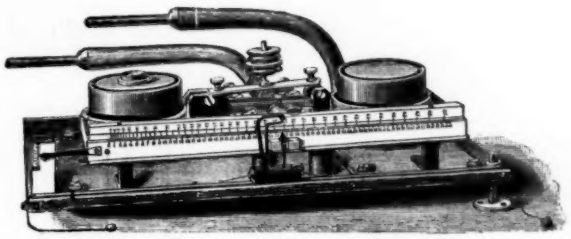

FIG. 1.—STANDARD HECTO-AMPERE BALANCE.

than the inner diameter of the movable ring, and the proportions are so arranged that the force experienced by the movable ring is very nearly constant through half a centimetre on each side of its middle position. This is the sighted position for the ordinary use of the balance; and it is marked by the zero line or middle one of five stout black lines across the scale traversed by the pointer of the balance.

6. In the balance instruments to measure alternate currents of all strengths, and direct currents of from

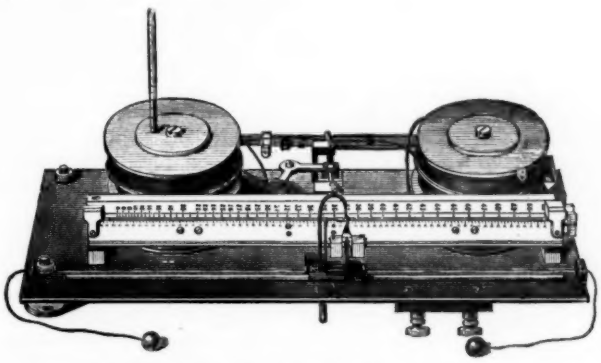

FIG. 2.—STANDARD CENTI-AMPERE BALANCE.

5 milliampères to 10 ampères (see fig. 2) the fixed rings are larger than in the instruments to measure the larger direct currents. Their outer diameters are greater and their inner diameters less than that of the movable ring which moves between them, above one and below the other. The position of the movable ring equidistant from the two fixed ones is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other,—in each case being nearer to the repelling than to the attracting ring by such an

amount as to give about $\frac{2}{10}$ per cent. more than the minimum force.

7. In the balance instruments to measure alternating currents (which may be also used for direct currents) of from 5 ampères to 1,000 ampères the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering or otherwise from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

8. The balancing is performed by aid of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right hand end of the balance, into which the proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time (§ 11 below). For the fine adjustment of the zero a small metal flag is provided (as in an ordinary chemical balance), actuated by a fork, with a handle below the case outside, as shown in the drawing (fig. 2). To set the zero, the weight is placed with its pointer at the zero of the scale, and the metal flag is turned to one side or the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

9. To measure a current the weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed scale (called the inspectional scale) with the aid of the finely divided scale, for more minute accuracy, according to the explanations given in § 13 below. Each number on the inspectional scale is twice the square root of the corresponding number on the scale of equal divisions.

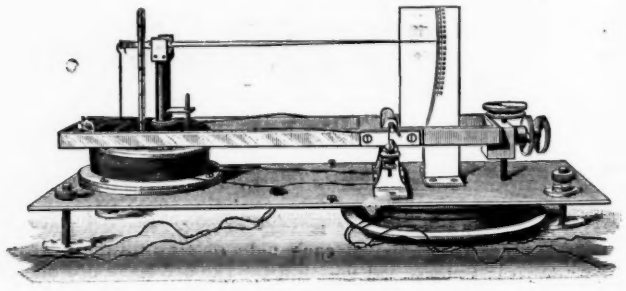

FIG. 3.—ENGINE ROOM VOLTMETER.

10. The slipping of the weight into its proper position is performed by means of a self-releasing pendant hanging from a hook carried by a sliding platform, pulled in the two directions by two silk threads passing through holes to the outside of the enclosure.

11. Three pairs of weights (sliding and counterpoise) in the ratios of 1 : 4 : 16 or 1 : 4 : 25 are supplied with each instrument; adjusted so that each pair gives a round number of ampères, or half ampères or quarter ampères, or of decimal sub-divisions or multiples of these magnitudes of currents, on the inspectional scale.

12. The useful range of each instrument is about from 1 to 25 of the smallest current for which its sensibility suffices. The ranges of the different types of this instrument regularly made are :—

I. Centi-ampère balance :	from	2 to 50	centi-ampères.
II. Deci-ampère	„	„ 1 to 25	deci-ampères.
III. Ampère	„	„ 1 to 25	ampères.
IV. Deca-ampère	„	„ 4 to 100	„
V. Hecto-ampère	„	„ 20 to 500	„

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the three pairs of weights :—

	I. Centi-ampères per division.	II. Centi-ampères per division.	III. Deci-ampères per division.	IV. Ampères per division.	V. Ampères per division.
1st pair of weights.	·25	1	1	·5	2·5
2nd „	·50	2	2	1·	5·0
3rd „	1·0	5	5	2·	10·0

13. The fixed inspectional scale shows approximately enough for many purposes the strength of the current; the notches in the top of the aluminium scale show the precise position of the weight corresponding to each of the numbered divisions on the fixed scale, and practically annul error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side, to the space between two divisions, may be estimated with considerable accuracy. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by one in the decimal place. But when the utmost accuracy is required the reading on the fine scale of equal divisions must be taken, and the strength of current estimated by aid of a table of doubled square roots appended to these instructions. Thus, for example, if the reading is 292 we find 34·18, or, say, 34·2 as the true scale reading for strength of current; or, again, if the balancing position of the pointer be 301 on the fixed scale we find 34·65 as the true reading of the inspectional scale.

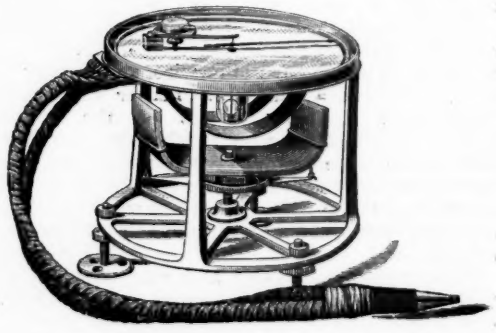

FIG. 5.—ADJUSTABLE MAGNETO-STATIC CURRENTMETER.

14. The centiampère balance, with a thermometer to test the temperature of its ampère rings, and with platinoid resistances up to 2,000 ohms, serves to measure potentials of from 10 volts to 200 volts.

DIRECT-READING VERTICAL SCALE VOLTMETER.

15. This instrument (fig. 3) is commonly called "engine room voltmeter," because it can be read at such a distance as across an engine room, and requires for taking a reading no balancing manipulation as in the balance ampèremeters. It is convenient not only for engine rooms, but for use in any part of an electric light installation, or in houses supplied with electric light. It shows, by inspection, whether the potential is exactly the proper amount, or, if not exactly so, by what fraction of a per cent., or by what percentage, down to 10 per cent. below, or up to 10 per cent. above, it differs from the proper amount.

16. The inspectional voltmeter consists of :—

a. A fixed platinoid resistance, in circuit with a fixed and a movable ampère ring.

b. A V-trough rigidly fixed to the movable ring, and carrying the weight proper to the potential to be measured and the temperature of the instrument.

c. A thermometer to show the temperature of the ampère rings.

d. A lever, multiplying the motion of the movable ring, and showing the potential to be measured on a vertical graduated scale.

17. The fixed and movable ampère rings are each com-

posed of many turns of fine insulated copper wire, with a total resistance of about 100 ohms. The amount of the added platinoid resistance depends on the potential to be measured in the ordinary use of the instrument. Thus, for example, for potentials of from 10 per cent. below to 10 per cent. above 100 volts, the platinoid resistance is 700 ohms; for potentials of from 10 per cent. below to 10 per cent. above 200 volts, the resistance is 1,500 ohms.

18. Temperature error is practically annulled in the use of the instrument by simply reading the thermometer (§ 14, *b* and *c*), and seeing that the weight in the trough is the one corresponding to the temperature. Five weights, corresponding to temperatures centigrade of 15°, 20°, 25°, 30°, 35°, are supplied with the instrument in receptacles marked with the temperature, so that no mistake can be made in seeing that it is the right weight that is in use on the instrument at any time.

MARINE VOLTMETER.

19. The mass of the moving part of the balance voltmeter and engine room voltmeter is too great to be convenient for sea use, and instead, a small oblate of soft iron, supported on a stretched platinoid wire in the centre of a solenoid of fine copper wire, connected in series with platinoid resistances, variable according to the potential to be measured, serves for marine voltmeter (fig. 4). A pointer carried by the oblate shows, by inspection, direct reading of currents of from 90 to 120 milliampères. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resistance is about 60 ohms), a total resistance of 1,000 ohms. Thus, the direct reading of potential on the scale is in volts.

20. This instrument is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. In the zero position the equatorial plane of the oblate is inclined about 45° to the lines of force of the solenoid, and torsion by the upper and lower parts of the bearing platinoid wire tends to turn it into a position perpendicular to the lines of force. This tendency is balanced by a stop against the needle when no current, or any current not exceeding 90 milliampères, passes through the solenoid. When a current exceeding 90 milliampères passes, the torsion couple is balanced by the couple due to the electro-magnetic force.

ADJUSTABLE MAGNETO-STATIC CURRENTMETER.

21. This instrument (fig. 5) has an advantage over the balance instruments, important for some practical purposes, of being available as an accurate direct-reading current meter, through a continuous range of from 1 to 90 or 100. Its disadvantages are that it is not available as an alternate current instrument, and that the magnetism of the steel directing-magnet does not remain absolutely constant. With good quality of steel, a proper preliminary *ageing* of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism may probably remain exceedingly nearly constant month after month and year after year. Still it can never be relied upon as absolutely constant. It is therefore necessary to have some means of accurately retesting and readjusting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance ampèremeters is available as a standard.

22. When the instrument is used as a lamp counter, primary adjustment, or readjustment at any time, can be performed with great ease, without the aid of any other measuring instrument, by turning the screw platform which bears the adjusting magnet, so as to raise it or lower it until it is found that the deviation from zero produced by the current of any number of lights shows a corresponding number on the scale of the instrument. After each motion of the magnet the zero of course must be readjusted, which can be done either by throwing off all the lamps, or throwing the instrument out of circuit, and then turning the magnet till the needle points to zero. The lower screw must be screwed firmly up to pinch the upper screw when the adjustment is completed. If this is done firmly enough the magnet may at any time, without scruple, be turned round on its platform and brought back again whether for setting the zero, or for any other purpose, as it is only by turning the upper screw that the distance of the magnet from the needle can be altered.

23. The scale has 100 divisions, corresponding to equal differences of tangents of the angle between the magnetic axis of the needle and the electro-magnetic axis-vertical of the rings. The divisions may be numbered from 0 to 100: but for many purposes it is convenient to number them from 30, 20, or 10, on the left, to zero, and from zero to 70, 80, or 90 on the right; because we thus have larger divisions in the neighbourhood of the zero than when it is taken at the extreme left of the

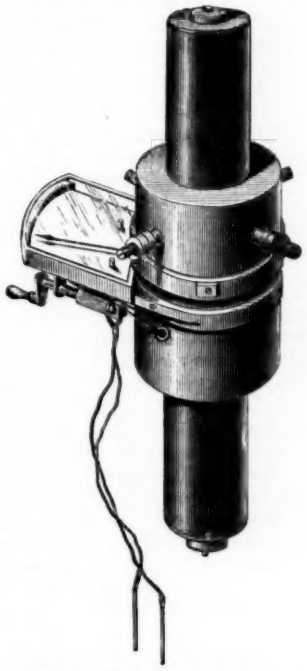

FIG. 4.—MARINE VOLTMETER.

scale, and because it is sometimes convenient to measure small currents in the direction opposite to that of the currents ordinarily measured. For most purposes probably the numbering 10 left to zero, and zero to 90 right, will be found most convenient. With scales so numbered any number of lamps from 1 to 90 can be counted by integral numbers of scale divisions. Of course this is not possible to any great accuracy, because the lamps are not all rigorously equal, but the lamp counter serves the important practical purpose of showing at any time the exact number of lamps in use when less than 10 or 15, and nearly enough for practical purposes the exact number however many there are. In private houses it is very useful as a check against some lamp or lamps being left accidentally alight in a cellar or safe-room or other place where the fact of its being alight might escape observation for days or weeks together.

24. To count larger number of lamps up to 1,000 or more the instrument is made with smaller rings of more massive conductor. The same proportionate accuracy is attained as with the 100-lamp counter.

ADJUSTABLE RESISTANCES OR MHO-OHM DRUM.

25. This is a combination of platinoid* conductors fulfilling the double object of an ordinary box of

* When the special purpose is the measurement of the conductivity of copper the conductors of the mho-ohm drum are made of copper instead of platinoid.

resistance coils in series, and the mho box by which a set of conductors can be connected any two or more of them in parallel so that their conductances† shall be added, instead of the resistances being added, as in the ordinary box of resistance coils.

26. The conductors are coiled anti-inductively‡ on a drum of thick sheet copper to serve the purpose not only of bearing them and forming the main support of the instrument, but also of conducting away with great freedom the heat that is generated in each coil through which the current is flowing at any time, and so equalising the temperature of the different coils. A copper sheath is fixed outside in metallic connection with copper partition rings which separate the different coils. This sheath serves the purpose of protecting the coils against damage and of spreading out the heat generated in each coil over a wide surface freely exposed to the external air, and so greatly diminishing the rise of temperature due to currents through the coils. It is also convenient for the application of a water jacket for laboratory or other purposes in which special care as to the temperature of the coils is needed.

27. All the resistances on the drum are connected in series by permanent solderings. The varying connections for the use of the instrument are made by circular copper cams, mounted on vertical copper shafts, connected by solderings and flexible strands with the soldered joints between the coils in series on the drum. Each shaft is mounted so as to work in two positions, an upper and a lower.

28. For making the mho connections all the shafts are placed in the upper position, and the connections are made by turning the cams so as to press on the outer or inner of two concentric copper rings between which the shafts and cams are mounted.

29. For the ohm connections the shafts are let down to their lower position, and the connections are made by turning the cams so as to short-circuit whichever of the coils are not to be included in the sum of the resistances in series. The working of this part of the plan is precisely the same as in the ordinary resistance box except that the short-circuitings are made with easier manipulation by cams with single contacts, instead of by removable plugs with contacts on each side of each plug. This halving of the number of the non-soldered contacts is a decided advantage.

and quarter ounces. Thus when the smallest single resistance on the drum is 1 ohm the other resistances are 2, 4, 8, 16, 32, 64, 128, 256, 512, 1,024, 2,048, 4,096 ohms : this last being the highest single resistance on the drum as ordinarily made, but higher resistances may be added if desired.

EXPLANATORY TABLE
For use of Mho-ohm Drum for Resistances.

Distinguishing Letters.		Resistances.
Block.	A	1 ohm.
	B	2 „
	C	4 „
	D	8 „
Italic.	*a*	16 „
	b	32 „
	c	64 „
	d	128 „
Roman.	A	256 „
	B	512 „
	C	1024 „
	D	2048 „
	E	4096 „

EXPLANATORY TABLE
For use of Mho-ohm Drum for Conductances.

Distinguishing Letters.		Conductances.
Roman.	E	$\frac{1}{2} \times \frac{1}{2048}$ of a mho.
	D	1 „ „
	C	2 „ „
	B	4 „ „
	A	8 „ „
Italic.	*d*	16 „ „
	c	32 „ „
	b	64 „ „
	a	128 „ „
Block.	D	256 „ „
	C	512 „ „
	B	1024 „ „
	A	2048 „ „

31. The dual system, besides its availability for the two modes of connection, has this advantage, that with it a smaller number of coils suffice than in any of the decimal systems of resistance coils ordinarily in use.

REPAIRING INCANDESCENCE LAMPS (PAUTHONNIER'S SYSTEM).

FOR some considerable time, in fact, we may say, since their invention, attempts have been made to find some practical means of repairing incandescence lamps. It is well known that after an average duration of from 700 to 800 hours the carbon filament, which is the essential element of the lamp, breaks, thus rendering the lamp useless. When we say that the lamps last from 700 to 800 hours, we (*Le Moniteur des Inventions Industrielles*) are speaking of the average dura-

TABLE *for facilitating the Addition of Resistances in terms of Ohms on the Mho-ohm Drum.*

	A	B	AB	C	AC	BC	ABC	D	AD	BD	ABD	CD	ACD	BCD	ABCD
Block ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic ...	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Roman + E	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840
	4352	4608	4864	5120	5376	5632	5888	6144	6400	6656	6912	7168	7424	7680	7936

TABLE *for facilitating the Addition of Conductances in terms of* $\frac{1}{2048}$ *of a Mho on the Mho-ohm Drum.*

	D	C	CD	B	BD	BC	BCD	A	AD	AC	ACD	AB	ABD	ABC	ABCD
Roman	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic...	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Block ...	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840

Adding E to any combination of the other conductances adds $\frac{1}{2} \times \frac{1}{2048}$ of a Mho to the sum.

30. In order that the single set of resistances may be available both for the connection in series (for ohms) and for the connection in parallels (for mhos) their proportions must be according to powers of 2, as in ordinary weighing by subdivision of the pound into halves, quarters, eighths, sixteenths (or ounces), and half

† This is Oliver Heaviside's word.

‡ That is to say, each wire is doubled on itself with the two parts everywhere close together, but well insulated from one another.

tion, for there are some in which the carbon only lasts a few hours, whereas others greatly exceed the time we mention, and the worst of it is, that there is no indication to show us when the rupture will take place. Now the price of these lamps is somewhat high, 4s. or 5s., or even more, and when we consider the number that would be required in a large installation, we can understand that this rapid consumption is one of the chief hindrances to the general adoption of this superb mode of lighting.

M. Pauthonnier, fully recognising the importance

attached to the practical solution of this problem, applied himself to the study of the subject, and at length, after numerous experiments, arrived at a successful result. In calling his solution perfect, we in no way exaggerate, for experience has shown that the repaired lamp is far superior to a new one.

But there is no occasion for lamp manufacturers to take fright and see, in M. Pauthonnier's method, an injury to their trade. It will act in quite a contrary direction. In our opinion the process will, in a short time, bring about the complete generalisation of electric lighting, and consequently a corresponding development of the manufacture of incandescence lamps. If we may use the comparison, the case will be exactly analogous to that of the reduction in price of postage stamps. When a stamp cost 75 centimes, the revenue arising from postage was much less than at the present day, when it costs 15 centimes. Why? Because when it cost 75 centimes people only wrote in cases of urgency, and about once a month, but now, on the contrary, they are writing nearly every day. It will be the same with the lamps. We hesitate at establishing an installation the cost of maintenance of which is enormous; but when that cost is reduced 60 per cent. the installation will be universally adopted.

One difficulty, and certainly not the least, was the opening of the glass bulb in which, as we know, the vacuum was obtained. If the opening is too sudden, the air rushing in violently strikes against the glass and shatters it. This difficulty was, therefore, the first consideration for the inventors,* and their researches led to the invention of a set of instruments which it would take too long to describe, but which gives them complete satisfaction.

This being the case, they proceed in the following manner:—

After having opened the bulb at the top, they draw together, by means of an instrument introduced into the aperture, the two pieces of carbon, until the broken edges are brought completely into contact again, so that the current may be re-established. They then fill the bulb with a hydro-carbon, and make the current pass through. Under its action the hydro-carbon is decomposed and pure carbon is deposited on the filament so as to solder the break, and the whole is strengthened, or rather, reconstituted. When treated by this process, not only is the duration of the filament protracted, but it acquires new properties, and it is a fact that whereas a new carbon loses in brilliancy with its duration, one which has undergone this treatment preserves its brilliancy during the whole period, which 90 times out of 100 far exceeds that of a new carbon.

And now we feel compelled to mention a consideration into which it is contrary to our custom to enter, but it is necessary, in this case, in order to show the value of the invention, and this is, that the inventors execute these repairs at the rate of 2 francs per lamp, that is to say, for less than half the price of the cheapest lamp. If we consider the number of lamps now working in France alone, we can easily see the enormous extent and value of this invention, which, unlike so many others, will, we sincerely hope, prove a fortune to its originators.

CABLE REPAIRS OFF THE CONGO.

THE Silvertown Company's telegraph steamer *Buccaneer*, Captain Thomson, has lately returned from the West Coast of Africa, where she was engaged, under the direction of Messrs. E. W. Parsoné and E. March Webb, in repairing the West African Telegraph Company's cable between Sao Thomé and Sao Paulo de Loanda.

We are informed that the cable parted in the gully off the Congo River in about 1,100 fathoms. This gully is a continuation of the river bed cut down through the shallow water plateau which extends along this part of the coast; it is narrow, deep, presents extremely steep gradients on both sides, and is traced as a ravine or gully to a distance of some 90 miles from land.

To place the cable in a safer position, it was necessary to divert it to a very great extent, and to effect this some 83 miles were picked up, of which 72 miles were subsequently relaid, in addition to 17 miles of new cable.

On the north side of the rupture the broken end was picked up, but the southern side of the break was apparently buried, one and-a-half miles being unrecovered. This, however, was the only cable lost throughout the operations.

Before attempting to divert the cable, several lines of soundings were taken at different points across the gully, in order to determine the most advantageous route. These profiles are very interesting, inasmuch as they show how the gully varies in direction, depth, and breadth. To acquire a thorough knowledge of the locality, it was found necessary to take some 150 soundings, the deepest being in a little over 1,400 fathoms.

The ship was three weeks on the ground, this period including a few days employed in turning over cable, splicing, &c., so as to adapt the different types to the exigencies of the situation, such as depth of water and nature of the ground.

We understand that Captain Thomson made a very complete series of observations with regard to the currents experienced off the Congo River. These should be valuable, as the information hitherto possessed as to these currents has been limited, and it is known that they vary in force and direction very considerably.

On the voyage home soundings were taken between the Islands of Anno Bom, Sao Thomé, Principe, and Fernando Poo, and a short cable was laid for the French Government between Dakar and the Island of Goree.

We are informed that the general health on board was exceptionally good throughout the trip, which lasted altogether nearly three months.

ITALIAN RED SEA CABLES.

THE following particulars with regard to the cables lately laid between Massowah, Assab, and Perim for the Italian Government may be of general interest.

Towards the end of 1885 the Italian Government entered into negotiations with the Eastern Telegraph Company for the connecting up of Massowah and Assab with its system. The company refused to entertain the proposals of the Government, giving as reasons, first, that its cable between Aden, Perim, and Suakim was too old, and had been too frequently repaired to bear any picking up or diversion; and, secondly, that at least 230 miles of new cable, of a heavy type, would be required.

Fresh negotiations with the company were commenced on the following bases:—Either the company would lay cables between Massowah, Assab, and Perim, without undertaking repairs or maintenance for a sum of 1,450,000 francs, or the company would lay the cables and maintain them for an annual subvention of 250,000 francs, with the condition that for any interruption to the cables a period of two months should be allowed without any loss of subsidy, that a further period of one month should be granted with the loss of one-half of the subsidy corresponding to that period, and that if the cables remained interrupted after these three months, the subsidy should cease until they were repaired.

The Government considered these conditions to be disadvantageous, and while they were being discussed the firm of Pirelli & Co., of Milan, made an offer to the Government which was accepted, the general conditions of the contract entered into between the Italian Government and Pirelli & Co., being as follows:—The

* We have no mention of the second inventor's name in the original article.—EDS. ELEC. REV.

Government pays to Pirelli & Co. an annual subvention of 240,000 francs for the laying and subsequent maintenance in good working order of two cables, that is to say, 200,000 francs for a cable between Massowah and Assab, and 40,000 francs for a cable between Assab and Perim.

The offices at Massowah and Assab will be in the hands of the Government, and the work at these places will be carried on by Government officials. At Perim the Eastern Company will carry on the work in consideration of an annual payment of 15,000 francs.

The contract is to last for 20 years, at the end of which period the Government becomes the absolute possessor of the cables without any further payment.

At any time during the operation of the contract the Government, should it so desire, may take possession of the cables in consideration of a payment to the company of 95,000 francs per annum for each year which the contract may still have to run.

In case of interruption to the cables, the company will lose during the first three months after the date of interruption, the proportionate amount of subvention corresponding to the interrupted cable. If the interruption lasts more than three months, the company will pay a fine of 2,000 francs per diem during the first 15 days beyond the three months, and 4,000 francs per diem during the following 15 days. If at the expiration of these extra 30 days the cables are still interrupted, they become the absolute property of the Government, as if the contract had duly terminated.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

WE have received the following letter, which we have much pleasure in publishing :—

"The Editor, TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW, London.

"Dear Sir,—As members of the Council of the American Institute of Electrical Engineers, as well as representatives of the electrical press here, we write to ask that you will so far as you may deem appropriate, and in such manner as suggests itself, lend aid to the movement recently started here to place the institute on a firm and enduring basis. The aim is to give the institute a standing such as that enjoyed by similar bodies on your side of the water, and another is to obtain a house for the institute. Although the movement has but recently taken shape, after three years' talk, over $4,000 has been contributed, and the money is coming in. A word or two from you will materially help on the work, which must commend itself to all interested in electrical science.

"Yours truly,

"GEO. M. PHELPS, Jun.
"The Electrician and Electrical Engineer.

"T. C. MARTIN.
"The Electrical World.

"115, Nassau Street, New York, *May 21st*, 1887."

We have to congratulate the promoters of the institute that there is now a probability of the latter being at last firmly established. The advantages which such a society offers to the electrical confraternity can hardly be over-estimated, and the fact that our own "Society of Telegraph-Engineers and Electricians," founded in 1872, now numbers considerably over 1,000 strong, and that this number is being continually augmented shows that these advantages are fully appreciated. The reading and discussion of papers, though, of course, the main object of such societies, is by no means the only reason for their existence, the bringing together of a number of men who would probably never otherwise meet, being a most important feature to be taken into consideration. As a means of indirectly educating the student of science, such societies are most valuable, as they not only cause the student to "think," but furnish him with means of obtaining information through the medium of journals and books, a reading room and library being an indispensable adjunct. To enumerate the various advantages which the subject of the institute suggests would occupy too much space, and therefore in conclusion, our hearty good wishes are given to the new enterprise, which we have no hesitation in saying should prove a great success and should receive the support of all who take any interest in electrical science.

THE SWINTON TELEPHONE.

LAST week we paid a visit to the offices of the Equitable Telephone Association, Limited, for the purpose of examining into the merits of the telephone system devised by and manufactured under the patents of Mr. A. A. Campbell Swinton, a gentleman well known by name to the attentive readers of our pages. Whether the apparatus used for transmitting the electrical impulses possesses a diaphragm or not, we will leave our readers to judge, or rather to speculate upon. Our own opinions upon the evidence of patent experts, scientific witnesses, and

FIG. 1.

the decisions of the various judges who have been called upon to set at rest the issues of several telephonic lawsuits, are too well known to need further comment, and we therefore proceed at once to describe the apparatus.

The transmitting instrument is very well shown in fig. 1, and it consists of a base board containing a microphone, bell, push button, and the usual switch lever, upon which hangs one of the receivers, the hook for the second receiver being a fixture. The multiple microphone is constructed of a number of small carbon rods, strung on a platinum wire, and placed vertically in a heavy lead frame; these rest at any angle, which can be adjusted at will, upon a horizontal carbon rod of

larger diameter, part of whose surface is electro-coppered for the purpose of making good connection with the leading wires, and which is insulated from its support. The microphone, as a whole, is suspended at a distance of about 1½ inches from the back-board by two India-rubber rods which are intended to cut off all vibrations from the woodwork. The operator speaks directly on the carbon rods, setting them in motion by the direct impact of the air impulses issuing from the mouth without any intermediary whatever, the lead being thought too heavy and inelastic to respond sensibly to the vibrations set up by the action of the voice. The amount of pressure normally existing between the vertical carbon pencils and the horizontal rod can be readily adjusted to a great degree of nicety by simply varying the inclination of the frame, the pressure increasing with the inclination, and *vice versâ*.

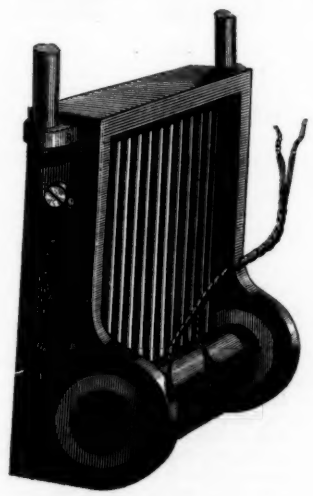

FIG. 2.

In practice the frame is suspended in an almost vertical position, so that the pressure is exceedingly light, and hence the microphonic regulators are rendered very sensitive, and the direct action of the voice upon

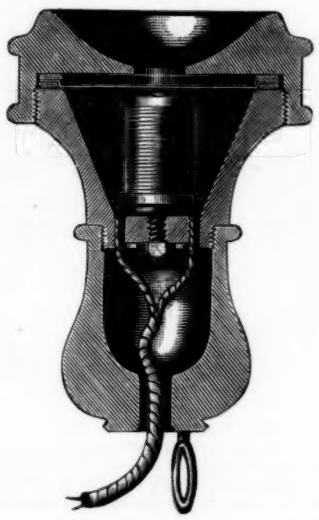

FIG. 3

the carbons has, of course, the important advantage of rendering the articulation in the telephone remarkably pure and distinct.

Fig. 2 represents the microphone detached from its support. The microphone answers equally well when suspended in space from a ceiling. In fact, to us the talking appeared louder, but as we were then listening upon another receiver, we do not attach any importance to this apparent increase in the volume of sound. The receivers are of the *English Mechanic* type (fig. 3), the electro-magnet being excited by the line current; for, no induction coil being employed, the system is direct working. The diaphragm is a thin sheet of vulcanised fibre with a thin disc of tinned iron of the size of a shilling attached to its centre.

As the apparatus is operated only by direct currents, the connections are naturally simple, and inductive effects do not cause any practical inconvenience.

We were much pleased with Mr. Swinton's system as a whole, and he has evidently taken great pains to produce a simple and reliable microphone, which at the same time shall necessitate the minimum of adjustment. Considerable ingenuity has also been shown in all the constructive details, care being taken to avoid complication in any form whatever. The apparatus can be seen at 75, Queen Victoria Street, and the Equitable Telephone Association is prepared to give an indemnity to purchasers of instruments which are sold outright and not rented, against all proceedings by other patentees of telephones. As the business transaction of the Association will not seriously affect those who hold the telephonic monopoly—for it is known that the U. T. Company does not sell telephones outright—it appears not only possible but probable that Mr. Swinton, considering the special character of his microphone, will not be pounced upon as an infringer of either Bell or Edison; but, *quien sabe?* At all events, we understand that the Association is fully prepared to fight, if such a course should be forced upon it. It is scarcely necessary to enumerate the various uses to which these instruments can be put, but for lines between head and branch offices, offices and works, offices and private residences, departments in factories and warehouses, &c., their applicability is obvious, and there are many other purposes for which a ready, reliable, and cheap method of personal intercommunication is invaluable.

Under any circumstances Mr. Swinton has our best wishes for the development of his simple and effective system.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

WE have received a letter with reference to the action of a member of the Council of the above Society in the matter of a paper which had been submitted for reading before one of the ordinary meetings. This letter contains so much which can only be characterised as personal abuse and is altogether of such a fantastic character that we cannot consent to publish it, though we have been desired to do so. There is a great tendency (not an unnatural one perhaps) for a writer to consider that his own views are correct beyond doubt, and that it is unjustifiable, or even impertinent, for anyone to differ from him, and this is especially the case, we think, in cases where the writer's paper or communication is addressed to some scientific society. It is the invariable custom in cases where a paper is submitted to such a society, to hand the same over to some member of the council (whom the latter considers to be best qualified to judge of the subject) to report whether the matter is of sufficient interest, or is dealt with in a sufficiently interesting manner, to justify the paper being read before one of the ordinary general meetings. There is, of course, the possibility that in certain cases a council member may allow himself to be swayed by personal motives and thus to have his judgment biassed, but such cases are, we feel sure, extremely rare, and it is far more probable that the complainant is himself the biassed individual. What the exact reasons are why the paper to which our attention has been called has been withheld we, not being in the secrets of the council, are unable to say, but as our correspondent informs us that the paper was a "big job" and that it contains "an account of the theoretical principles involved and of various effects observed and their explanation," "the whole being

supplemented by *three lengthy* appendices," we can quite understand that it may have been considered unadvisable to take up three or four evenings with a long-winded discourse which would probably severely tax the patience of any ordinary audience. The Society of Telegraph Engineers has, in the course of its existence, had experience of more than one paper which has been read without having been sufficiently considered by the council in the first instance, and the result has been that it has not been deemed advisable to repeat the experiment. A member submitting a paper to a scientific society ought to know what is the practice as regards its acceptance, and he submits it at his own risk, and must be prepared for the consequences, just as he must be if he takes a case before a court of law, the judge of which *may* be biassed.

In addition, we may remark that it does not always follow that a paper is "burked" because it is not read during any one session. It has probably been shelved for a more convenient opportunity, or the pruning knife may still be at work in bringing it down to reasonable dimensions. In conclusion, we would ask, why do not writers of papers, whose contributions are rejected or held over from session to session, request their return, and publish them in technical journals? Readers could then judge, providing the papers are accepted, whether the society had been the loser or not by the action of its council.

NOVEL PHENOMENA OF ALTERNATING CURRENTS.*

By PROF. ELIHU THOMSON.

THE actions produced and producible by the agency of alternating currents of considerable energy, are assuming greater importance in the electric arts. I mean, of course, by the term alternating currents, currents of electricity reversed at frequent intervals, so that a positive flow is succeeded by a negative flow, and that again by a positive flow, such reversals occurring many times in a second, so that the curve of current or of electromotive force will, if plotted, be a wave line, the amplitude of which is the arithmetical sum of the positive and negative maxima of current or electromotive force, as the case may be, while a horizontal middle line joins the zero points of current or electromotive force.

It is well known that such a current passing in a coil or conductor laid parallel with, or in inductive relation to a second coil or conductor, will induce in the second conductor, if on open circuit, alternating electromotive forces, and that if its terminals be closed or joined, alternating currents of the same rhythm, period or pitch, will circulate in the second conductor. This is the action occurring in any induction coil whose primary wire is traversed by alternating currents, and whose secondary wire is closed either upon itself directly or through a resistance. What I desire to draw attention to in the present paper are the mechanical actions of attraction and repulsion which will be exhibited between the two conductors, and the novel results which may be obtained by modifications in the relative dispositions of the two conductors.

In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about six inches in diameter and about twenty inches long. They were made of bundles of iron rod of about $\frac{5}{16}$ inch diameter. When complete the magnet was energised by the current of a dynamo giving continuous currents, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet copper, of about $\frac{1}{16}$ inch thickness and 10 inches in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc even when the attempt was made by holding one edge of the disc in the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole, a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction to those in the coils of the magnet, and which currents, of course, would cause attraction as a result.

* Read at the annual meeting of the American Institute of Electrical Engineers, at New York, May 17th.

The experiment was, however, varied, as in fig. 1. The disc, D, was held over the magnet pole, as shown, and the current in the magnet coils cut off by shunting them. There was felt an attraction of the disc or a dip toward the pole. The current was then put on by opening the shunting switch and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place,

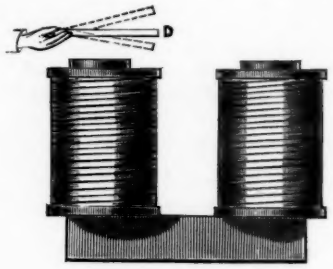

FIG. 1.

currents had been induced in the disc, D, in the same direction as those in the magnet coils beneath it, and when repulsion took place, the induced current in the disc was of opposite character or direction to that in the coils.

Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given we will find that the disc, D, is attracted and repelled alternately; for, whenever the currents induced in it are of the same direction with those in the inducing, or magnet coil, attraction will ensue, and when they are opposite in direction, repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc, D, in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disc, D, and the magnet coil. The disc might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings or coils superposed, and the results would be the same. Thus far, indeed, we have nothing of a particularly novel character, and, doubtless, other experimenters have made very similar experiments and noted similar results to those described.

The account just given of the effects produced by alternating currents, while true, is not the whole truth, and just here we may supplement it by the following statements:

An alternating current circuit or coil repels and attracts a closed circuit or coil placed in direct or magnetic inductive relation therewith; but the repulsive effect is in excess of the attractive effect.

When the closed circuit or coil is so placed, and is of such low resistance metal that a comparatively large current can circulate as an induced current, so as to be subject to a large self-induction, the repulsive far exceeds the attractive effort.

For want of a better name I shall call this excess of repulsive effect the "electro-inductive repulsion" of the coils or circuits.

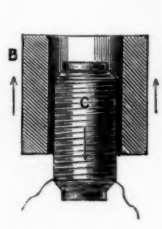

FIG. 2.

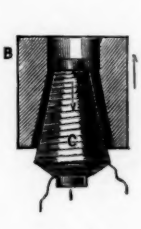

FIG. 3.

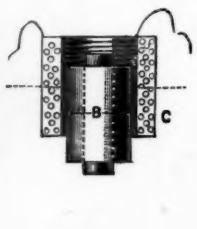

FIG. 4.

This preponderating repulsive effect may be utilised or may show its presence by producing movement or pressure in a given direction, by producing angular deflection as of a pivoted body, or by producing continuous rotation with a properly organised structure. Some of the simple devices realising the conditions, I will now describe.

In fig. 2, C is a coil traversed by alternating currents, B is a copper case or tube surrounding it, but not exactly over its centre. The copper tube, B, is fairly massive and is the seat of heavy induced currents. There is a preponderence of repulsive action tending to force the two conductors apart in an axial line. The part, B, may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire insulated, or not. If the coil, C, or primary coil, is provided with an iron core such as a bundle of fine iron wires, the effects are greatly increased in intensity and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

The forms and relations of the two parts, C and B, may be greatly modified with the general result of a preponderence of repulsive action when the alternating currents circulate.

Fig. 3 shows the part, B, of an internally tapered or coned form, and, C, of an externally coned form, wound on an iron wire bundle, I. The action in fig. 2 may be said to be analagous to that of a plain solenoid with its core, except that repulsion, and not attraction, is produced, while that of fig. 3 is more like the action of tapered or conically wound solenoids and taper cores. Of course it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action and the amount of repulsive effort existing at different parts of the range.

In fig. 4 the arrangement is modified so that the coil, C, is outside, and the closed band or circuit, B, inside and around the core, I. Electro-inductive repulsion is produced as before.

It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are co-incident. In cylindrical coils in which the current is uniformly distributed through all the parts of the conductor section, what I here term the electrical middle, or the centre of gravity of the ampère turns of the coils, will be the plane at right angles to its axis at its middle, that of B and C in fig. 4 being indicated by a dotted line. To repeat, then, when the centres or centre planes of the conductors, fig. 4 coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced, a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion, and distribution of current at any time in the two circuits or conductors.

It is not my purpose now to discuss the ways of determining the distribution of currents and mechanical effects, as that would extend the present paper much beyond its intended limit. The forms and relative arrangement of the two conductors may be greatly varied. In fig. 5 the parts are of equal diameter, one, B, being a closed ring, and the other, C, being an annular coil placed parallel thereto, and an iron core or wire bundle placed in the common axis of the two coils increases the repulsive action. B may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

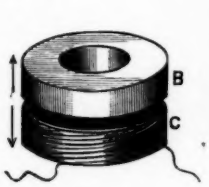

FIG. 5.

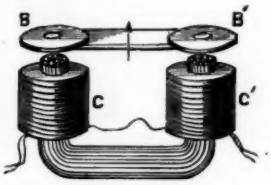

FIG. 6.

An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in fig. 6. The alternating current coils, C, C′, are wound upon an iron wire bundle bent into U form, and opposite its poles is placed a pair of thick copper discs, B, B′, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, &c.

If the iron core takes the form of that shown by, I, I, fig. 7, such as a cut ring with the coil, C, wound thereon, the insertion

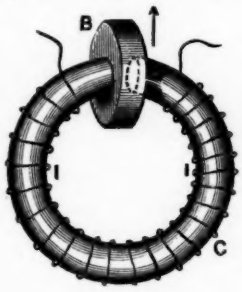

FIG. 7.

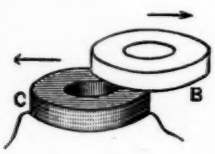

FIG. 8.

of a heavy copper plate, B, into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in C. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate, B, out of the slot in the ring excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which B is placed.

If the axis of the conductors, fig. 5, are not coincident but displaced, as in fig. 8, then, besides a simple repulsion apart, there is a lateral component or tendency as indicated by the arrows. Akin to this is the experiment illustrated in fig. 9. Here the closed conductor, B, is placed with its plane at right angles to that of C, wound on a wire bundle. The part, B, tends to move toward the centre of the coil, C, so that its axis will be in the middle plane of C, transverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i.e.*, deflective actions.

When one of the conductors, as B, fig. 10, composed of a disc, or better, of a pile of thin copper discs, or of a closed coil of wire, is mounted on an axis, X, transverse to the axis of coil, C, through which coil the alternating current passes, a deflection of B to the

FIG. 9.

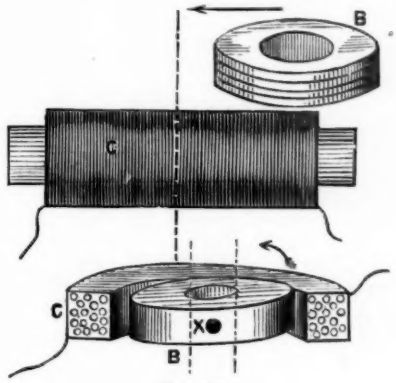

FIG. 10.

position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil, C, encloses the part, B, or be enclosed by it, or whether the coil, C, be pivoted and B fixed, or both be pivoted. In fig. 11 the coil, C, surrounds an iron wire core and B is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.

It is important to remark here that, in cases where deflection is to be obtained, as in figs. 10 and 11, B had best be made of a pile of thin washers or a closed coil of insulated wire instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring, B, in other directions than parallel to its circumference.

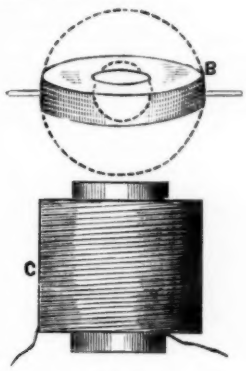

FIG. 11.

We will now turn our attention to the explanation of the actions exhibited, and afterwards refer to their possible applications. It may be stated as certainly true that were the induced currents in the closed conductor unaffected by any self-induction, the only phenomena exhibited would be alternate equal attractions and repulsions, because currents would be induced in opposite directions to that of the primary current when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

This condition can be illustrated by a diagram, fig. 12. Here the lines of zero current are the horizontal straight lines. The wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The vertical dotted lines simply mark off corresponding portions of phase or succession of times.

Here it will be seen that in the positive primary current descending from m, its maximum, to the zero line, the secondary current has risen from its zero to m^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum, n, the positive current in the secondary closed circuit will be decreasing from m^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repulsion, and again an attraction, during one complete wave of the primary current. The letters, r, a, at the foot of the diagram, fig. 12, indicate this succession.

In reality, however, the effects of self-induction in causing a lag, shift, or retardation of phase in the secondary current, will

considerably modify the results, and especially so when the secondary conductor is constructed so as to give to such self-induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in fig. 12 had been shifted forward to a greater or less extent. This is indicated in diagram, fig. 13. It gives doubtless an exaggerated view of the action, though from the effects of repulsion which I have produced I should say it is by no means an unrealisable condition.

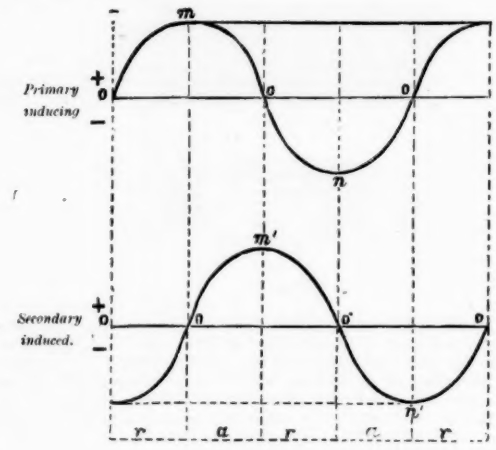

FIG. 12.

It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the same direction for attractive action. These differing periods are marked *r*, *a*, &c., or the period during which *repulsion* exists is from the zero of the primary, or inducing current, to the succeeding zero of the secondary, or induced current; and the period during which *attraction* exists is from the zero of the induced current to the zero of inducing current.

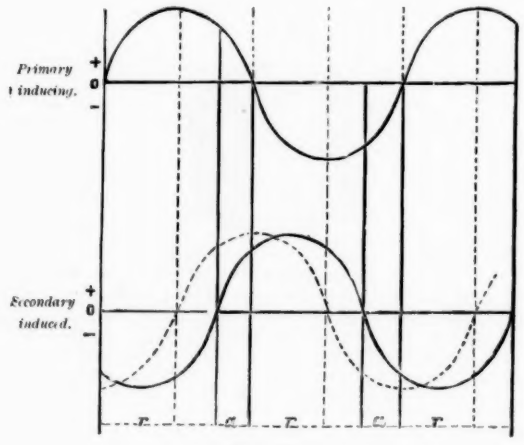

FIG. 13.

But far more important still in giving prominence to the repulsive effect than this difference of effective period is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a *repulsion due to the summative effects of strong opposite currents* for a *lengthened period* against an *attraction* due to the summative effects of *weak currents* of the *same direction* during a *shortened period*, the resultant effect being a greatly *preponderating* repulsion.

It is now not difficult to understand all the actions before described as obtained with the varied relations of coils, magnetic fields, and closed circuits. It will be easily understood, also, that an alternating magnetic field is in all respects the same as an alternating current coil in producing repulsion on the closed conductor, because the repulsions between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them.

Thus far I have applied the repulsive action described in the construction of alternating current indicators, alternating current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators, a pivoted or suspended copper band or ring composed of thin washers piled together and insulated from one another and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents whose amount or potential is to be indicated. Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say, 15 degrees to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current, and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same manner as electro-magnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating current motor which can be started from a state of rest the principle has also been applied, and it may here be remarked that a number of designs of such motors is practicable.

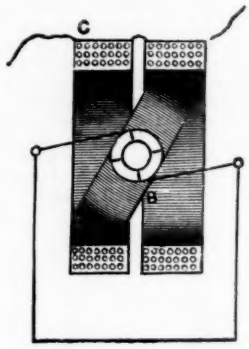

FIG. 14.

One of the simplest is as follows:—The coils, C, fig. 14, are traversed by an alternating current and are placed over a coil, B, mounted upon a horizontal axis, transverse to the axis of the coil, C. The terminals of the coil, B, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to keep the coil, B, on short circuit from the position of coincidence with the plane of C, to the position where the plane of B is at right

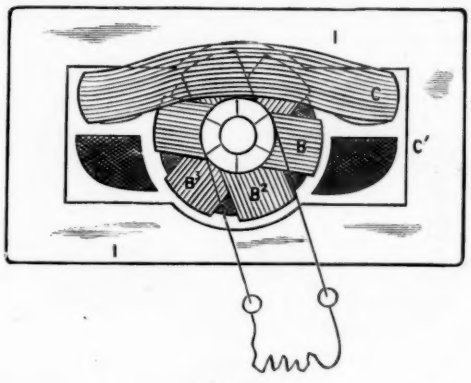

FIG. 15.

angles to that of C; and to keep the coil, B, open-circuited from the right angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by B will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of C, but being then open-circuited its momentum carries it to the position just past parallelism, at which moment it is again short-circuited, and so on. It is capable of very rapid rotation, but its energy is small. I have, however, extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet iron discs wound as usual with three coils crossing near the shaft. The commutator is arranged to short-circuit each of these coils in succession, and twice in a revolution, and for a period of 90 degrees of rotation each. The field coils surround the armature and there

is a laminated iron field structure completing the magnetic circuit. I may say here that surrounding the armature of a dynamo by the field coils, though very recently put forth as a new departure, was described in various Thomson-Houston patents, and to a certain extent all Thomson-Houston machines embody this feature.

Figs. 15 and 16 will give an idea of the construction of the motor referred to. C, C^1, are the field coils or inducing coils which alone are put into the alternating current circuit. I, I, is a mass of laminated iron, in the interior of which the armature revolves, with its three coils, B, B^2, B^3, wound on a core of sheet iron discs. The commutator short-circuits the armature coils in succession in the proper positions to utilise the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point and will start from a state of rest and give out considerable power, but with what economy is not yet known.

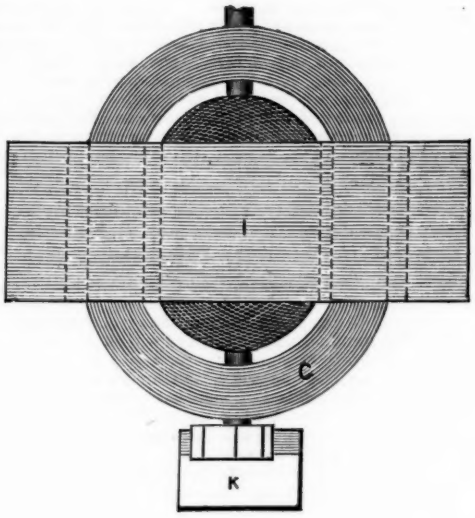

FIG. 16.

A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil, C, a continuous current passes from one commutator brush to the other, and it will energise electro-magnets and perform other actions of direct currents. Here we have, then, a means of inducing direct currents from alternating currents. To control the speed and keep it at that required for the purpose, we have only to properly gear the motor to another of the ordinary type for alternating currents, namely, an alternating current dynamo used as a motor. The charging of storage batteries would not be difficult with such a machine, even from an alternating current line, though the losses might be considerable.

MR. MAILLOUX: I might add, in corroboration of the statement made by Prof. Thomson, that I am perfectly aware myself that the ironclad dynamo, as we have heard it called very recently, is another of those things that have been done before. I remember distinctly reading one of Prof. Thomson's patents where the direct magnetising effect of the coil on the armature itself is adverted to, and I do not think there can be any dispute as to the fact that it had been brought out before; and I would also state that I myself made experiments with dynamos in which the same thing was made out as early as 1879, and I have small models now which may be of interest at some later time. There is one very interesting feature of it that is mentioned by Prof. Thomson. I think it is the phenomenon which he illustrated by means of his first figure, noting the repulsion and the attraction that takes place when the current is reversed in an ordinary electro-magnet. I could not help thinking, at the time, of some experiments made some years ago by Elphinstone and Vincent, and about which I once took it into my head to write something. The effect was brought out by Elphinstone and Vincent, of the magnetic circuit that we now so well know and use in dynamo-electric machines. I was very much struck by the statement of Faraday in his *Experimental Researches*, where he speaks of lines of force expanding during the action of the beginning of the passage of current through a circuit and of their collapse when the current is discontinued or decreased; and I remember making a note in this article (which you will find somewhere in the London *Electrician*, several years back) of experiments or observations made by me to show that that phenomenon was observable in an ordinary electro-magnet. I have been able, by means of a delicately suspended needle, or by a very thin piece of iron wire fastened to the pole—so that it might place itself in the lines of force and follow the oscillations of the lines of force—to trace a positive motion in the lines of force which would exactly correspond to that just referred to by Prof. Thomson; in a word, when the electro-magnet is in the process of magnetisation, when the current is passing through it, there is an expansion of the lines of force starting apparently from the yoke, and the effect of the motion of these lines of force reacting on the disc would be such exactly as would produce repulsion in accordance with the phenomenon of Lenz's law. On the contrary, there is a collapsing process of the lines of force in the process of demagnetisation, and the action would be again such as to produce attraction or the dragging of the disc with it. Now, with regard to the difference of repulsive and attractive effect, there is another fact which I think Prof. Thomson has not taken into consideration, and which to some extent increases the difference of repulsive effect. If we assume for a moment that the process of expansion and collapse of lines of force is true—and I have no reason to doubt that is—then we shall readily see that as our current is put on we are dealing with several quantities. First, the resistance of the medium to the stress that is produced by the current; and second, the amount of energy or the rate at which we supply energy to overcome that elasticity. I might also add, of course, a third quantity, which is reaction produced by self-induction of surrounding metal; but when the collapse takes place we have the pent-up energy that has been stored by the process of contraction. I might explain this by taking a piece of rubber and stretching it. The rapidity with which it is stretched depends upon the rate at which energy is applied to it and the elasticity; but when I let go it falls back by virtue of its own elasticity, and nothing else. In the case of the secondary coil we can deal with this self-induction, but there are experiments which have been made, I think by Prof. Von Beetz, which show very clearly that the impulse of collapse is much more rapid than the impulse of rise. Consequently there would be a difference of current in the inductive circuits which would tend, if we follow them carefully by means of the curves produced by Prof. Thomson, to emphasise that difference of action in favour of repulsive process.

MR. PRESCOTT: Prof. Thomson has so clearly and beautifully described the experiments he has made that he has left hardly anything to be asked. I would say that I am particularly interested in the application to measuring instruments, and I would like to know whether, in the application he has discovered, the repulsion is inversely proportional to the square of the distance between the plates, and if so, whether he has preferred to make his instruments to measure that distance directly, *i.e.*, based on the distance directly, or whether he has preferred to counter-weight, or in some way counteract the movement so as to keep it always constant. He has paid so much attention to this question of alternating currents that I should like to ask him also whether he has ever made any experiments to determine, for instance, whether a secondary battery in the circuit of an alternating current machine would cut off a portion of the electromotive force in one direction which was counter and equal to that of the battery itself, in which case an ordinary current instrument would measure the resistance if connected around the poles of the battery.

PROF. THOMSON: In regard to the measuring instruments, I have used the principle in several ways. The matter has not been carried sufficiently far as yet to determine all the points on the subject, but I have used gravity and a spring in both cases. However, I find there does not seem to be any regular law, perhaps any more than there is with an electro-magnet, for the decrease of the effect by distance, except when the distances become very large. The very fact of a change of position changes the relations of the currents themselves and of the relations between the two currents, so that we can hardly regard the problem as any different from the problem of an electro-magnet attracting its armature. When the armature is placed at a certain distance, there is a certain distribution of magnetism; when it is taken to another distance the distribution is so changed that we could not consider that the centre of gravity, so to speak, of the magnetism, is the same in the two cases, and the re-distribution will depend on the length, the diameter of the core, and the sizes of the armatures, so that the problem becomes a very

FIG. 17.

complex one. But I have made a very curious application of the principle in this way: I have taken an ordinary fruit jar and put in it a disc of a certain thickness, and attached to it a bulb of glass, and floated it in alcohol or water until the gravitational effect was so overcome by the flotation that it was almost indifferent, but it would just settle down to the bottom of the jar (see fig. 17). I then put an alternating current coil below it and passed a current of gradually increasing amount. Gradually the disc would begin to lift itself, and at a certain current would float to a certain height, standing in the liquid supported by the repulsion. There we have a very excellent illustration of the means of getting at probably the relational effect of repulsive effort under different conditions. In regard to the point

brought up by Mr. Mailloux, concerning the more rapid drop in the current at the end of a wave, I think that he must have been considering the effect of interrupted currents only in that case—the ordinary induction coil. That is, you put on a primary current on a primary coil, put on a battery current and the counter electromotive force keeps it down and it slightly rises to the current which it would have with the electromotive force present acting with the resistance of the primary wire. But when you cut off the current, the secondary current is much more vigorous in electromotive force, but does not last as long. In the primary coil, surrounded by its secondary, when we put on the current or close the circuit there is an opposing electromotive force; the battery does not get its full amount for some time, and during that time the secondary currents will seek to evolve their energy; that is, they have duration without great force. But when we cut the battery current off, and do it specially with a condenser, which enables us to remove the contact without sparking, or, in other words, to cheat the current a little and give it another pass for the time being, the secondary then gives out considerable energy. I may mention an interesting experiment in this connection, showing the effects of self-induction on magnets—a very curious experiment tried with a large magnet. It has not anything to do with the repulsive effect; it has to do with self-induction and the curious effects produced by it in lagging or stopping waves and preventing waves from having their full value. We put this magnet into circuit with the dynamo, and we take a shunt of carbon points—a shunting switch made with carbon as they might be in an arc light. The current comes through this way (illustrating on the blackboard) when the shunting switch is open and goes out. We close the switch, and of course the current gradually leaves the magnet, and gradually it flows in nearly full volume over the carbon points in accordance with their resistance. If their resistance is much less than the magnets all the current will flow over the carbon points. Now, the arc formed here, instead of being a good, strong full arc, will simply be the tops of the waves of the current, while the steady current will flow through the magnet. That is, you will have a steady current in the magnet and the tops of the waves will be chopped off and sent through the carbon. There is no self-induction in this branch and the current there is steady. In fact, the spark you get here and the arc you get there will very closely resemble the spark obtained from the Ruhmkorff coil—a thin spark with a considerable aureola and not very hot. I have drawn them three-quarters of an inch long, playing and spluttering, showing that their waves are having their true value in regard to undulations of sound, whereas an ammeter put in shows a current pretty nearly equal to the line current.

Mr. PRESCOTT: In regard to the secondary battery and the alternating current circuit?

Prof. THOMSON: That is a question that I have not investigated at all, but there would be a current of double volume in one direction and a stoppage in the other direction, provided the volts of counter electromotive force were right. There is a possibility of producing a current of this character by combination of an alternating current machine and a dynamo and a continuous current machine. We may have a current like that (illustrating) produced, which would be somewhat the current that you were asking about. Whether application of such currents will ever be made or not I do not know.

Mr. PRESCOTT: The point I wanted to make is a little different. Suppose that an alternating current is passing through that wire (illustrating) and that at this point here we introduce an electromotive force, or we introduce a certain electromotive force in one direction and we have got no resistance in circuit with it, and connect it up *here*. Now, suppose this point be shifted until the difference of potential all in one direction of this alternating current is equal to the electromotive force of this cell *here*; then there will be a current of one direction only through this wire, and if that is the case you have got a known resistance in *here*; you have simply to interpose an electromotive force in one direction and shift it along until you get no deflection in the galvanometer, in which case you could determine, of course, half the electromotive force of the alternating current. Something like this was suggested to me by Mr. John Howell, of the Edison Company, and he wanted me to try it. It is a very recent matter, and I have not had an opportunity of trying it yet.

Mr. JOHN M. PENDLETON: In regard to the secondary battery application that the gentleman has just made, I should fancy the result would be the steady discharge of the battery of whatever charge it might have; but it would be impossible to aggregate chemical energy in the battery under the circumstances, I should incline to believe. While I was listening to Prof. Thomson's interesting account of his experiments in the matter, it occurred to me that if the actions are sufficiently delicate in the matter described, there is a great variety of applications, several of which he mentioned, and it appeared to me that it would be possible, in connection with the telephone, to make a recording instrument of that, which might, at any rate, equal the success of the phonograph. In this case it would be a reproduction of the waves of sound in the same manner. I merely make the suggestion in addition to those that Prof. Thomson made.

Mr. CARL HERING: I would like to ask Prof. Thomson how the magnetic attraction compares with its induction. If the closed copper disc were to be made of iron, there would be attraction; now, how does that attraction compare with the repulsion in case it is not magnetic? I ask that in order that we may get some idea of the strength of this repelling force.

Prof. THOMSON: I have not made any determinations with that object in view; that is, to determine the relation as to—as I understand it—the attraction of the magnet coil for its core. I think we can say, however, that it compares very well, only that the copper band, of course, naturally occupies a greater space and uses energy of current flowing in it. If we have a current flowing in a coil attracting an iron core, and the iron core is thoroughly divided so as to avoid currents in the iron itself, we shall get electro-magnetic attraction pure and simple without necessary loss of energy; but in the case of the copper band there is undoubtedly, where large work is being done, a loss of energy due to the flow of heavy currents in the conductor; but in the case of a disc which is deflected, the disc saves itself that loss by throwing itself more or less at right angles. It is only when you are resisting the motion by a counterweight that the loss amounts to a great deal. Allow the thing to move, and it relieves itself of the stress by leaving the point of greatest stress.

Mr. J. A. POWERS: I had a very interesting experience in the line of Prof. Thomson's address about the lag of heavy currents, which I wish to bring to your notice. At Troy we are making an alternating current dynamo, producing direct currents from it; in other words, a simple multipolar dynamo, with this exception, that the armatures are in two layers, the neutral point on one armature corresponding with the maximum point on the other. Those two armatures are connected to a single commutator, there being two bars connected with one armature and the next two bars with the other; the positive of one and the positive of the other; the negative of one and the negative of the other; in that relation a brush being put on of a certain width we found some curious results. With plating machines of low tension, we found we could increase the width of contact to such an extent that we seemed to collect the entire current from both sides of the armature; in other words, the current seemed to be prolonged from each side of the armature so that we were practically collecting the current from both sides. The moment we got to high tension currents we failed. Without apparent lag of the current, or whatever that was, the minute we increased the tension of currents up to two or three or four hundred volts, we failed entirely. But the point that I wished to bring to your attention was that we could make that contact of considerable width and apparently get a larger power from the same amount of material in the machine in low tension work than we could when we got too high tension, and apparently there existed there this feature of lag of heavy currents which Prof. Thomson first brought up.

Prof. THOMSON: I do not think you can say that heavy currents lag any more than light currents. A heavy current is nothing more or less than the flowing around of so many light currents. In the closed circuit of a coil it is the same current going round many times as compared, you may say, with parallel currents which represent the current that goes in the fine coil repeated side by side so many times; and the lag ought to be the same in both cases. I find, for example, that it does not matter in these experiments whether I use a copper ring or a closed coil of a finely-wound coil; I might use No. 36 wire, provided I could get as much copper into the same space with No. 36 wire as I could get with a heavy mass of copper. That, of course, I cannot do, but if I could, I have not the slighest doubt that the high electromotive force closed on this would have the same lag as heavy currents closed on this. In one case it has greater length; in the other it has greater volume, which lags the current. Mr. Powers is probably working with high potentials in one case and quite low potentials in the other. Now a high potential machine is a ticklish thing to handle anyhow. You must put your brushes on and carry the coil away not a moment too late or you will have a flash and short circuit of the commutator from one point to the other. I am speaking of the type of machine you refer to. The low potential current, however, permits you to have a considerable variation in the point of connection without provoking bad sparking and flashing; you no doubt need to put the extra overlap of brushes brought on the coils into action at the moment they are developing very low electromotive force, and take them out when they are developing nearly no electromotive force. That you could not do in a machine of that type with high potentials, because if you keep the coils in beyond their time of possessing electromotive force which could just sustain the circuit, you would have a flash; there would be an alternation at the slot in the commutator which would cause a reverse current.

Mr. POWERS: The action I was speaking of was not flashing at the commutator, but the curious "growling" of the machine against itself; for instance, the relation between 10 volts and 100 volts on the same machine if you choose to couple them up directly, and the same brushes would give you that slowing down and growling effect, while in the other case, the brushes worked smoothly and gave good results.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION AND CAPACITY.*

By W. E. SUMPNER, B.Sc.

IT has long been known in a general way that the effects of self-induction and capacity are opposite in kind. Self-induction in a

* Read in the discussion which followed the reading of Professors Ayrton and Perry's paper on "Modes of Measuring the Coefficients of Mutual and Self-Induction," before the Society of Telegraph-Engineers and Electricians, May 12th, 1887.

relay produces sparking, but if a condenser be shunted to the relay sparking is prevented. Condensers are used in induction coils to prevent sparking and to hasten change of magnetisation. Mr. Preece told us while discussing Professor Hughes's paper that a resistance shunted by a condenser is placed in a telegraph circuit to overcome the effects of self-induction. Professor Silvanus Thompson told us (Journal, May 13th, 1886) that Mr. Black in 1878 "showed that one difficulty in long-distance telephoning could be effectually got over by putting a condenser in the circuit as a bridge to any electro-magnet in the line." The reason of this is possibly that the condenser diminishes the effective self-induction of the line. Mr. Blakesley remarked on the same occasion that the working of a telephone circuit completed through a condenser could be improved by adding self-induction to the circuit up to a certain amount. After that maximum had been reached, an increase of the self-induction of the circuit or a diminution of its capacity would be a disadvantage. Now possibly the reason of this is to be found in the fact that capacity is like a negative self-induction. Capacity in a circuit helps change of current. Self-induction in a circuit hinders change of current. Just as self-induction in a telephone circuit retards some of the waves of current more than others, and thereby renders impure the sounds given out, so capacity in a telephone circuit accelerates some of the waves more than others, and produces a similar result. The ideal telephone circuit should have no effective self-induction. What the resistance of it is does not matter so much. When Mr. Blakesley added self-induction to his telephone circuit, the improvement he noticed in the working was probably not because the mere addition of self-induction was an improvement, but because the effect of the capacity was diminished more and more as self-induction was added, until a point was reached when the effect of the latter counterbalanced that of the former. It was then that the line worked at its best. It was then that the waves of current travelled along the line without changing much in form.

In working with the secohmmeter it is possible to make the resistance of the coil having self-induction appear either to increase or to decrease, according to the way in which the commutator is turned. It is even possible by turning the sechommeter at a particular speed to reduce the apparent resistance of the coil to zero. The reason is that self-induction when currents are increasing acts like an increase of resistance, and when currents are diminishing like a diminution of resistance. Exactly the reverse holds good of capacity. In the armature of a dynamo self-induction acts like an increase of resistance because the current has to be started in each coil as it passes the commutator. If it were practicable to shunt each coil of the armature by a condenser, the effect of capacity would be that of a diminution of resistance each time the coil passed the commutator. Just as the resistance of an armature is effectively increased by its self-induction, and increased by an amount proportional to its speed, so the result of capacity would be to diminish the effective resistance by an amount proportional to the speed. If, therefore, it were practicable to use condensers of suitable capacity, it would be possible not only to get rid of the effect of self-induction, but actually for a particular speed to diminish the effective resistance of the armature to zero.

It is important to consider whether the opposite natures of self-induction and capacity can be utilised practically in diminishing the self-induction of transformer circuits.

In the appendix of the paper of Professors Ayrton and Perry will be found two or three methods which I devised for measuring self-induction. In each of those methods a condenser, shunted to the coil, was used to prevent sparking at the intervals between the reversals; and although the condenser was afterwards dispensed with because a short circuit was allowed to occur, yet the formula was first worked out in each case on the supposition that the condenser was used. The result came out in every instance just as if the condenser had been absent, and as if the self-induction of the coil had been diminished by the product of the capacity of the condenser and the square of the resistance of the coil shunted to the condenser. Now this not only showed that each of the methods for measuring self-induction was also a method for measuring capacity, but it seemed to indicate that there was some law regulating the external action of a condenser shunted by a wire.

The law was easily found to be as follows:—

In any network of conductors, if one of the branches be composed of a condenser whose terminals are shunted by a wire, with or without self-induction, and if the currents in the network vary from any cause from one steady set of values to another, the extra quantity of electricity which will pass through a galvanometer placed in any arm of the network, in consequence of the capacity, will be exactly as if the condenser were altogether removed and the self-induction of the wire were diminished by the product of the capacity of the condenser and the square of the resistance of the wire shunting it.

Let E be the electromotive force, constant or variable, applied to the terminals of a condenser through a resistance, R; let K be the capacity of the condenser, r the resistance, and L the coefficient of self-induction of the wire shunting the condenser; let x be the current through the wire r, and y the current through the condenser, and let V be the potential difference of the condenser terminals at any moment: then

$$E - V = R(x + y)$$

$$V = r x + L \frac{dx}{dt},$$

whence

$$y = K \frac{dV}{dt};$$

$$E = (R + r)(x + y) + (L - K r^2) \frac{dx}{dt} - K L r \frac{d^2 x}{dt^2}.$$

The extra current due to K and L will be that caused by the extra electromotive force

$$(L - K r^2) \frac{dx}{dt} - K L r \frac{d^2 x}{dt^2},$$

and the total quantity of electricity passing through a galvanometer placed in any other branch of the network will be proportional to the integral of this extra electromotive force. If the currents in the network vary from one steady state to another, the integral is

$$(L - K r^2)(x_1 - x_2),$$

where x_1 and x_2 are the two steady currents through the wire. Now, as these are not affected by K, the effect on the galvanometer is exactly as if the condenser were removed and the self-induction of the wire were diminished to

$$L - K r^2.$$

The effect of the capacity is that of a negative self-induction. It may be said to be due to this cause that it is possible to compare self-induction with capacity in the way described by Clerk Maxwell.

It seems very strange that Clerk Maxwell, who devised a method for measuring self-induction absolutely, and who also gave methods for comparing self-induction, mutual induction, and capacity, failed to observe that his absolute method was equally applicable to the measurement of all these quantities. If a galvanometer be placed in one of the branches of any network of conductors, such as the Wheatstone bridge, the effect on the galvanometer due to different electromotive forces acting in different branches of the network is well known to be the sum of the effects produced by each electromotive force acting separately. Now the effect of self-induction in a wire through which a varying current is passing is to generate an electromotive force in the wire proportional to the rate at which the current varies. Mutual induction and capacity produce similar effects. So that, while currents are being established in a Wheatstone bridge in and between the branches of which exist induction and capacity, the extra current through the galvanometer will be that caused by the extra electromotive forces in the network, and will be the sum of the extra currents produced by each of these electromotive forces taken separately. The total quantity of electricity going through the galvanometer in consequence of the induction and capacity will be a simple linear function of the coefficients of those quantities.

Indeed, Maxwell has shown that if self-induction exists in one of the arms of a Wheatstone bridge which is balanced for steady currents, the fling of the galvanometer when the galvanometer circuit is closed before the battery circuit, is directly proportional to the self-induction. He has, moreover, shown that it is possible to balance the bridge for both steady and variable currents, provided a certain relation holds between the resistances of the arms and the coefficients of induction or capacity that are being compared. If, for example, as in fig. 5, we are comparing self-induction with capacity, suppose L is the self-induction of the branch, r, and K is the capacity shunted to the branch, q, and if $p s = q r$ and $K q r = L$, Clerk Maxwell has shown that the bridge will be balanced for both steady and variable currents. Now this shows that the effect of K is equal and opposite to that of L; and since the swing of the galvanometer when K is removed is proportional to L, it follows that the swing of the galvanometer when L is removed is proportional to K. The same remark applies to mutual induction. It at once follows that Clerk Maxwell's method of determining self-induction in absolute measure is also a method of determining mutual induction and capacity in absolute measure. We have merely to proceed in exactly the same way as when determining self-induction, and to divide the result we obtain by a simple ratio or a simple product of the resistances in the arms of the bridge.

Perhaps Clerk Maxwell missed seeing this because he foresaw the existence of null methods and did not consider the meaning of the galvanometer swing when the bridge, although balanced for steady currents, was not balanced for variable currents. However this may have been, the null methods of Clerk Maxwell form an example of how very tedious and difficult to work null methods may sometimes become. It is not only necessary to have a very delicate galvanometer and an extremely delicate adjustment of the bridge, but only one particular adjustment of the bridge will give any result at all, and for this reason these double null methods are quite unsuited to those to whom time is any object.

Once, however, the fact is grasped that the swing of the galvanometer in a bridge balanced for steady currents is a linear function of the inductions and capacities in the bridge, it is easy to see a much more rapid way of comparing the coefficients than by the methods of Clerk Maxwell.

Let L_x be the self-induction of the branch, x; let K_x be the capacity of the condenser shunted to the branch, x; let M_{xy} be the mutual induction of the branches, x and y.

If we are comparing L with M, as in fig. 6, we have

$$L_s + \frac{p+r}{p} M_{sb} = k D_1,$$

where p and r are the resistances of the branches as indicated in the figure, D_1 is the first swing of the galvanometer when the bridge being balanced for steady currents has an electromotive force suddenly put in the battery circuit, and where k is some constant.

Now reverse the connections of either of the coils possessing mutual induction. The bridge is not altered except that the sign of M_{sb} is changed. If we now take another swing, we get

$$L_s - \frac{p+r}{p} M_{sb} = k D_2;$$

whence

$$L_s : M_{sb} = \frac{p+r}{p} \cdot \frac{D_1 + D_2}{D_1 - D_2}.$$

If we are comparing two self-inductions, as in fig. 1, we get in the same way after balancing the bridge,

$$p L_s - r L_q = k D_1.$$

Now remove the branch, q, and substitute resistances till the bridge is again balanced. We then have

$$p L_s = k D_2;$$

whence

$$\frac{L_s}{L_q} = \frac{r}{p} \cdot \frac{D_2}{D_2 - D_1}.$$

If we are comparing two capacities, as in fig. 3, which represents a generalised form of De Sauty's method, we have in the same way (if the bridge is balanced for steady currents)

$$s K_s - q K_q = k D_1;$$

by removing the connections of the condenser, q, we have

$$s K_s = k D_2,$$

or

$$\frac{K_q}{K_s} = \frac{s}{q} \cdot \frac{D_2 - D_1}{D_2} = \frac{r}{p} \cdot \frac{D_2 - D_1}{D_2}.$$

This must hold when the resistances, s and q, are infinite—*i.e.*, in De Sauty's method. In this case, however, as well as in the case represented in fig. 2, the swing method is needless, as a single null method is applicable.

If we are comparing capacity with mutual induction, as in fig. 4, we get in the same way

$$\frac{q+s}{q} M_{rb} - q r K_q = k D_1;$$

and by disconnecting the condenser we get

$$\frac{q+s}{q} M_{rb} = k D_2$$

or

$$M_{rb} : K_q = \frac{q^2 r}{q+s} \cdot \frac{D_2}{D_2 - D_1}.$$

If we are comparing self-induction and capacity, as in fig. 5 we get

$$L_r - q r K_q = k D_1;$$

and by removing the condenser,

$$L_r = k D_2,$$

$$L_r = \frac{D_2}{D_2 - D_1} q r K_q.$$

$q r$ must generally be large, and it is better to make q larger than r.

The following table gives the results of a set of experiments made on an induction coil the ratio between whose coefficients of self and mutual induction was required. The ratio $r : p$ of the arms of the bridge was varied from 50 to 200, the ratio of the coefficients being about midway between these numbers.

MUTUAL INDUCTION AND SELF-INDUCTION.

Ratio of arms r/p.	Induction measured.	Mean swing.	Sum of swings.	Ratio L : M.	Error from mean.
57·10	L − 58·1 M	209	774	126·3	0·9
	L + 58·1 M	565			
71·77	L + 72·8 M	601	765	127·4	0·2
	L − 72·8 M	164			
82·15	L + 83·1 M	595	720	127·4	0·2
	L − 83·1 M	125			
100·77	L + 101·8 M	594	659	126·8	0·4
	L − 101·8 M	65			
127·07	L + 128·1 M	545	542	126·7	0·5
	L − 128·1 M	−3			
206·99	L + 208 M	531	406	128·5	1·3
	L − 208 M	−125			
			Mean =	127·2	0·6

On looking at the column headed "Sum of swings," we see that the numbers gradually diminish to the null position. Now these numbers in each case correspond with the constant amount of induction, 2 L, and must therefore be a measure of the sensibility of the arrangement of the bridge. The striking fact comes out that in this particular case the double null arrangement was that of least sensibility. The reason of this is not far to seek. In measuring resistance by the Wheatstone bridge the sensibility, for the same galvanometer and battery, depends upon the way in which the bridge is arranged. Now the effect of induction or capacity for variable currents is exactly comparable with that of a variable resistance; so that the bridge, although balanced for steady currents, may be regarded as deranged for variable currents, and the effect on the galvanometer will be greatest when the bridge is joined up for the measurement of resistance in the most sensitive way. It by no means follows that the most sensitive arrangement of the bridge will be the particular arrangement necessary for the null position.

It therefore becomes questionable whether the double null arrangement is worth the trouble of getting. Those who invariably prefer null methods make an assumption which is not true. They assume no less than the possession of a galvanometer of infinite sensibility. All they really have is one galvanometer which is the most sensitive at their disposal, and the best arrangement they can have is that which will, with that particular galvanometer, yield the most sensitive results. However, those who have an extremely sensitive galvanometer or an extremely unreliable battery can use this method of swings merely as an approximation to indicate the null position, and may thereby save much time.

There is a more important consequence of the fact that the extra current through the galvanometer is a linear function of the coefficients of induction and capacity. All Maxwell's comparative methods may be turned into absolute methods, and either Maxwell's absolute method, or, still better, the absolute method of Profs. Ayrton and Perry, can be applied to each one of them. Figs. 1 to 12 illustrate this.

(To be continued.)

THE TELEGRAPH VOTES.

THE House of Commons went into Committee of Supply on the Civil Service Estimates on Monday, Mr. Courtney in the chair. On the vote of £4,820,770 to complete the sum neccessary for the Post Office,

Mr. BRADLAUGH complained of the manner in which promotion in the department was carried out. The regulations laid down that the principle should be promotion by seniority, having reference to fitness; but some recent promotions in the Post Office in London seemed to disregard both these considerations, while in Liverpool some promotions had been made by the Postmaster there in which, for apparently personal reasons, men who were unfit, and who had no claims of seniority, had been promoted over the heads of those who had both qualifications. He asked the Postmaster-General to say whether it was not possible, especially in the telegraph department, to dispense with some of the men drawing high salaries and apportion the money to the men whose pay was what he called a starvation wage.

Mr. H. HEATON said that he intended to move at a later stage the reduction of the vote by the amount of the salary of the secretary of the Post Office. He believed that all the blame for what the hon. member for Northampton had complained of rested on official heads. There had been a conflict between the Postmaster-General and the secretary of the Post Office, and an address of sympathy was got up in the Post Office by the secretary to himself, and it was signed by all the officials. At one time it was a question whether the Postmaster-General should resign or not, for it seemed that if the right hon. gentleman persisted in his opposition to the official heads he must inevitably go to the wall. He suggested that arrangements should be made for establishing in England a system of telegraphic money orders. This was in force in every country in Europe except England, and in all the colonies. It was one of the simplest operations possible, and would benefit the Post Office. But through obstinacy and desire to avoid trouble on the part of the Post Office officials obstacles were thrown in the way of the carrying out of that necessary reform.

Mr. RAIKES, in reference to what had been said by the hon. member for Northampton, stated that in sanctioning the different promotions that were made in the service of the Post Office, he was guided according to the circumstances of individual cases, by considerations of fitness, of seniority, and of fitness coupled with seniority as well as to some extent by the advice of officers on the spot. These considerations applied whether the cases arose in Liverpool or elsewhere, and no hard-and-fast line could be adopted in exercising the patronage which the Postmaster-General possessed in the matter. The hon. member for Canterbury (Mr. H. Heaton) had made reference to a matter which he had hoped had passed into oblivion. He would, however, advert to it in reply, lest it should be supposed that he had anything to regret in the course he had taken in regard to it. He referred to the irregular proceeding in the Post Office shortly after he became Postmaster-General, and which he hoped all the parties who had participated in it had since regretted. He had felt bound to vindicate the honour of the office he now held, and

having vindicated it, he had been perfectly satisfied to let the matter rest, and he trusted to secure the cordial co-operation and assistance of those very able gentlemen who formed the permanent staff around him. The hon. member had also referred to the question of telegraphic money orders. He would deal with that when they came to the telegraphic vote; but he might say that, although there were advantages in the system, it was attended with very great risk, in so far as increasing largely the balances in the hands of provincial postmasters was concerned.

The CHANCELLOR of the EXCHEQUER protested, in the interests both of the revenue and of economy, against the doctrine that it would be a good arrangement to come to an understanding that any surplus beyond a certain revenue from the Post Office should be utilised in improvements. Improvements in the Post Office ought to be considered quite apart from the question whether there was a surplus revenue or not. While speaking of the very considerable profit of the Post Office it must be remembered that it was a diminishing profit, and regard must be had to economy as well as to efficiency. Moreover, the working expenses of the office had increased during the last five or six years from 57 per cent. to 65 per cent. of the receipts. He had thought it right to make these remarks in the interests of the revenue, though it must not be understood that he desired to detract from the wish of the Government to give every possible facility to the development of the postal and telegraphic service of the country.

Mr. S. LEFEVRE would fix the limit of profit at £3,000,000, and would allow the surplus profit to be used for improving the service.

Mr. RAIKES said there was a mistaken idea as to the surplus revenue of the Post Office. The gross revenue had increased, but the cost of the service had increased in even a greater ratio. The surplus paid into the Exchequer last year fell short of the surplus in the preceding year by more than £300,000. The decline in the finances of the Telegraph Department, which commenced about four years ago, had continued steadily to increase. There was a deficit in the telegraph revenue last year of between £220,000 and £230,000. At present the taxpayers were paying £550,000 to assist the senders of telegrams. He was sorry to say that false telegrams were not infrequently sent, and he often wished that he had some power to deal with the offender. It was only the other day that a complaint was made to him by the owner of a horse that was expected to make a considerable show in the Derby to the effect that some one had sent a false telegram to the Jockey Club to say that the horse was scratched. It was not easy to detect offenders in these cases, for the people who sent these telegrams were not always careful to identify themselves.

The committee divided, and the numbers were:—

For the reduction	31
Against	111
Majority against	—80

The vote was agreed to.

On the vote of £1,500,248 for the Post Office Telegraph Service, Dr. CAMERON urged the advisableness of revising the bargain made in respect of telegraphs many years ago, and of inquiry as to the amount of waste thereby incurred, particularly with reference to the charges made by railway companies and others for the maintenance of telegraph wires.

Mr. MOLLOY inquired what progress had been made in putting telegraph wires underground, with a view to avoiding the inconvenience caused by breakdowns of overhead wires, especially when great storms occurred.

Mr. H. HEATON suggested that the twenty years' monopoly of the Submarine Cable Company, which expired next year, should not be renewed, but that the cables to the Continent should be owned by the Government.

Mr. RAIKES considered that it was practically not within the bounds of equity for the House of Commons to seek to review an arrangement legally made and entered into with the railway companies as to the maintenance of postal wires. The Government could not, without a breach of equity, attempt to interfere with the arrangement with railway companies for the maintenance of telegraph wires. He was not prepared with the actual figures of the extent of our present system of underground telegraphic communication. The Government, was, however, developing that system, especially in London and in large towns. The network of wires seen in London were for the most part not telegraph wires under the control of the Government, but were the property and under the control of telephone companies. The country would hardly sanction a general extension of the underground system, the lowest estimate for which was put at £1,500,000. There were undoubtedly certain dangers from the overhead system, but there was the advantage of greater facility for repair The question was being carefully considered, and the Department were of opinion that in the Metropolis and in large towns underground wires might with advantage be substituted for overhead wires. He called attention to the wonderful celerity with which the damage to the overhead wires last Winter was repaired, and expressed the acknowlegment of the Department to the Royal Engineers for so ably seconding the efforts of the Department. Negotiations had already begun as to the policy that should be adopted when the concession to the Submarine Cable Company came to a natural end. He hoped that the Committee would not press for any more positive statement of policy. There was a very full recognition of the paramount importance of the Government having control over the means of telegraphic communication with the Continent.

Dr. CAMERON complained that directors of railway companies made use of the privilege of franking telegrams for other purposes than the regulation of traffic. As the Postmaster-General did not seem to attach sufficient importance to the subject, he moved to reduce the vote by £25,000.

The committee divided—

For the reduction	60
Against	132
Majority against	—72

Mr. S. LEFEVRE asked whether the £500,000 deficit on the introduction of sixpenny telegrams did not include £350,000 interest on the capital embarked in the purchase of the telegraph system, together with £150,000 or £200,000 for new plant. If this were so, was he not right in saying that an actual increase in revenue had followed the introduction of the sixpenny telegrams?

Sir W. HARCOURT said the net profit of the Postal and Telegraph services was becoming less and less every year. He should be glad to learn what hope there was of the Telegraph service paying its way.

Mr. RAIKES said the position was this, that they had a permanent charge against the revenue of £326,000 interest on capital, plus the actual deficit on the working of £223,000. So that, on the whole, the figures came out for last year as representing a deficit of something like £550,000. A very large portion of the expenditure last year was due to plant, using the word in its largest sense. The number of telegrams sent for some weeks past had exceeded a million per week, compared with 70,000 or 80,000 in the corresponding period of last year, when the sixpenny telegram was introduced. The figures showed that the sixpenny telegram was almost in its infancy, yet the progress which it had made was so rapid that it was almost impossible to forecast the dimensions of its growth. It was impossible to say whether the introduction of sixpenny telegrams had really paid its way or not. Last year they produced a considerable increase of revenue, but there had also been a considerable and a larger increase of expenditure. It was hoped that while, in the course of the coming year the revenue would continue to increase, the expenditure would be largely diminished. That being so, he looked with some hope to the future of the sixpenny telegram. It must, however, be seen that demands for fresh sites, accommodation and plant must disturb any calculations which might be made.

Mr. S. LEFEVRE said the statement of the Postmaster-General was rather reassuring with regard to the future, showing that the actual number of telegrams had increased to a much greater extent than had been expected, but the average receipt was less, and the two apparently about balanced each other. He suggested that the payments of large amounts of expenditure should be spread over a period of years, so as not to disturb the averages.

The vote was agreed to, and progress was reported.

THE ROYAL JUBILEE EXHIBITION, MANCHESTER.

THE FAIRY FOUNTAINS.

DURING the Whitsuntide holidays the many visitors to the Manchester Exhibition were much attracted by the "Fairy Fountains," constructed and exhibited by Messrs. W. and J. Galloway and Sons, of Manchester. A display of the fountains is given each afternoon, when the variations of the numerous powerful jets form an attractive show. In the evening after dusk the fountain is illuminated, and a marvellous combined effect is produced, greatly to the amazement of the Lancashire and Yorkshire folk, who have in their thousands visited the exhibition during the past week.

Some further details of the construction and working of this fountain will not be uninteresting. The basin, which is 120 feet in diameter, is ornamented round the circumference by 12 neat pilasters supporting elegant vases designed by the architects. In the centre of the basin the pit for the fountains was excavated, consisting of a circular brick-lined pit 8 feet deep and 40 feet in diameter, benches being provided for supporting the lamps. This pit is connected by a subway 100 feet long with the manipulating tower. This subway, whilst providing a means of access to the basement, also acts as a culvert for the flow and return water pipes, and through it are also carried all the wires for the bells, signals, &c., from the observer's room in the manipulating tower, and the main cables from the dynamos to the arc lamps. By this arrangement everything is easily accessible, alike for examination and alteration or repair if necessary. The brick-lined pit or excavation is decked with timber, supported on stout wooden framing, and made water-tight by sheet lead carefully puddled in clay, above which

is a concrete bed finished with cement. This forms the bottom of the fountain basin. In the centre of the basin is a cast-iron box, closed at the top with a thick sheet of plate glass, placed just above the level of the water. Around this and arranged in two concentric circles are 16 similar boxes. In order to screen these boxes from ordinary view, rockwork is built round them. Underneath the centre box are placed two arc lights, and under each of the others is one arc, so that there are 18 arc lamps, fixed horizontally. These are regulated by hand and are arranged in groups of three each. Under the skylight and over each lamp are arranged slides, containing the coloured glasses, six in number. The slides are arranged so that any variation or combination can be immediately brought into play. A controlling apparatus is connected with the whole of the slides by pulleys of suitable diameter, and any one of the pulleys can be turned through a portion of its circumference, carrying with it the slides in connection with the same. This is effected by means of levers, provided with cross bars, upon which some movable stops slide, arranged in such a manner that when any particular series (simple colours or colours in combination) has been arranged, the bar automatically revolves, and the previously-used slides are taken off by means of the movable stops previously arranged. The combination of colours and the variation of slides are arranged by signals from the operator in the manipulating tower to the attendant below. This operator also has the complete control over the variation of the jets, and pressure of the water through the numerous nozzles. The operating room is in the upper portion of the tower, and contains a system of levers (not unlike those in a railway signal box), telephones, bell calls, coloured signals, and the necessary communication between himself and the fountains and also the engine room, so that the engines can be started and stopped, and it is also possible to count the speed of the engine. In the basement of the tower is the electrical room, into which the numerous wires from the dynamos enter, also the other wires requisite for the work. The usual electrical instruments required for testing, &c., are fixed here.

From the pumps, a distance of about 70 yards, the water (under a pressure varying from 10 lbs. to 100 lbs.) is conveyed by a number of suitable pressure pipes, which terminate in a distributing box, provided with a series of valves (connected by wires with the levers in the operating room), which control the different systems of jets. From these valves a series of pipes is fixed in the fountain basin and connected to the jets. The arrangement of jets is somewhat in this form: the central jet, with a nozzle of about 2 inches, has a ring of small jets immediately surrounding it; around this combination is a circle of jets with smaller nozzles, each jet being surrounded with a ring of small jets as in the central jet; outside all is another circle of jets, each one being separately surrounded by a small ring of jets. The effect of the separate jets is to form a column of water of varying size and power, according to the size of the nozzle and the amount of pressure, whilst the effect of the separate ring of small nozzled jets is to produce a feathery or fern-shaped appearance, which is extremely charming. A novel and peculiar misty effect is obtained by means of a perforated steam pipe, considerably adding to the fairy-like appearance of the fountains. It is needless to point out that these jets are fixed relatively to the arc lights, so that the most brilliant illuminating effects are obtained. We are informed that with full pressure a height of 150 feet can be obtained from the central nozzle, but we are not aware that anything nearer than about 120 feet has been obtained. The 18 arc lamps are extremely powerful, and are actuated each by a current of about 60 ampères from two Siemens dynamos. Each dynamo is capable of giving a current of over 450 ampères, with an electromotive force of 250 volts, when running at the rate of 300 revolutions per minute. The dynamos are driven by one of Messrs. Galloway's compound horizontal engines of 200 indicated horse-power, on their well known twin system, having cylinders of 20 inches and 26 inches respectively, and a stroke of 30 inches. This engine, we may remark, was one of the three engines Messrs. Galloway had last year at the Colonial and Indian Exhibition to work the dynamos for illuminating the grounds and fountains. The pumps consist of a double set of three-throw pumps, capable of delivering 200,000 gallons of water per hour, worked at either side of a three-throw shaft, the shaft being connected without the intervention of gearing to the crank or flywheel of the engine.

The various details of the arrangements for the simple manipulation of the fountains and of the illuminating coloured slides, have been carefully worked out by Mr. Beckwith, manager of Messrs. W. and J. Galloway and Sons, Knott Mill Iron Works at Manchester, to whom the greatest credit is due for the simplification of details, whereby large economy has been effected by the employment of a considerably reduced amount of labour. This simplification of detail extends not only to the facile manipulation of the fountain jets with varying pressure, but also to the more easy and rapid manner of working the slides as originally adopted by the late Sir Francis Bolton, to whom the special credit of the first introduction of this class of illuminated or "fairy" fountain must belong, and with whose name it must always be associated.

Special praise must be awarded to the Messrs. Galloway for their enterprise in producing a "fairy" fountain on such an extensive scale and with so many important improvements, tending not only to the economy and simplicity of its working, but also to the greater brilliancy and beauty of the general effects. The electrical arrangements for the working of the fountains have been from the commencement under the charge of Mr. Schultz, who is well known in connection with the several exhibitions held at South Kensington.

NOTES.

Electric Lighting at a Naval Ball.—At a ball given on board the torpedo school ship *Vernon*, at Portsmouth, on Friday night, there being present nearly 600 guests, the electric light was used to great advantage in enhancing the brilliancy of the decorations. A string of small incandescent lamps ran round the entire circuit of the ball-room, which measures 100 feet by 40 feet, and by way of precaution against any possible breakdown, there were also suspended from the ceiling several large groups, each containing eight electric lights of 40 C.P. each. The refreshment room was illumined by three groups of eight 40 C.P. lights, and a large incandescent lamp of 500 C.P. In the centre of the room stood a large block of ice, weighing 2 cwt., inside which burned an electric light. The various approaches were also brilliantly lighted by electricity, and on shore, at the point of embarkation for the *Vernon*, three powerful arc lamps were used, so that the guests could enter and leave the steam launches without danger. The whole of the lighting arrangements were carried out by the officials of the ship.

Electric Lighting of Belgian Railway Stations.—A project, says *Industries*, is under consideration by the Railway, Posts, and Telegraphs Department, for the complete lighting, by electricity, of the Brussels-Nord station, and tenders will be shortly invited. The electric light will also be adopted at the Quartier Leopold station, in Brussels, for the waiting rooms, platforms, and shunting yards.—The lighting at the Midi station has been improved, partly by the introduction of the electric light, and partly by the employment of more intense gas burners.

Church Illumination.—The cathedral of Coire, in the canton of the Grisons, has recently been fitted up with the plant necessary for electric lighting.

Fire caused by the Electric Light.—A *Times* Vienna telegram of date May 30th, states :—"A rumour spread rapidly this evening that the Burg Theatre was burning. A fire had, in fact, broken out, but not in the old Burg Theatre, where a performance was just going on, but in the new Burg Theatre in course of construction. The provisional electric cable caught fire, and about 25 yards of it were destroyed beneath the stage. Fortunately the whole of the fittings there consist of iron and stone, so that any further damage was almost impossible. It appears that the accumulators were being charged for to-morrow, the work beneath the stage being done under the electric light. There seems, however, to have been a weak spot somewhere in the cable, so that the current broke through, catching the wooden cover. The fire was soon noticed, and easily extinguished by the fire brigade."

Lighting of the Brussels 1888 Exhibition.—The technical sub-committee of the 1888 exhibition has decided, *Industries* states, to light the machinery department by means of electricity. No decision has been come to in reference to the system to be employed.

Electric Light in New Orleans. — The long and bitter struggle between the gas and electric light companies in New Orleans has come to an end, the municipal council of that place having contracted with the Louisiana Electric Light Company for the lighting of the town by electricity.

Electric Lighting of the Law Courts.—By the sanction of H.M. Office of Works, Messrs. Baily & Grundy were able, on behalf of the Incorporated Law Society and the refreshment contractor, to turn the dreary corridors of the Law Courts into a veritable fairy land upon the occasion of the recent banquets of the Law Society. Palms, rhododendrons, and other plants profusely adorned the corridors, and amongst these were some 150 incandescent lamps with glasses of various colours, the effect created being one of singular charm. One point worthy of notice is that neither staples nor hooks were permitted in the installation. Messrs. Henry F. Joel & Co. have supplied and fitted their improved Pilsen arc lamp for the lighting of the Great Hall, where they are successfully run in parallel arc with the incandescent lamps in the courts and corridors. This firm has also recently supplied its improved Pilsen arc lamps to the Admiralty, London University, Apothecaries' Hall, Victoria Station, and to several mills for use in dye-houses.

Ship Lighting.—The screw steamship *Meteor*, just recently launched for the London and Edinburgh Shipping Company, went on her trial trip on Monday. Specially constructed for the service, she has been fitted with the latest improvements, including 110 electric lamps and Sir William Thomson's patent compass and sounding gear.

Gas and Electricity in St. Petersburg. — The St. Petersburg correspondent of the *Manchester Courier*, states that the Duma of St. Petersburg has conceded to the gas company there the right of lighting the streets and private dwellings by electricity as well as with gas. After the lapse of 20 years both the gas and electric plant becomes the property of the Government.

Electric Light at Saltburn-on-Sea.—An extensive installation of incandescent electric lighting has just been completed in the public gardens of this Yorkshire watering place. The underground mains were laid by Callender's Company, and Messrs. W. H. Holmes and Company, of Newcastle-on-Tyne, are the contractors.

Electric Lighting Prospects.—From rumours which reach us, we think there is but little doubt that a considerable development in lighting from central stations will shortly be seen. Isolated installations also appear to be in demand, and business generally looks promising.

Theatre Lighting.—The shocking catastrophe at the Paris Opéra Comique, upon which we commented in our last issue, is not being ignored. We learn that the Mayor of Lyons has issued a decree for the theatres of that city to be lighted up by electricity within a term of five months. After that date, any establishment which neglects or refuses to conform to the regulation, will be officially closed.

The Paris Municipal Council has passed a resolution granting a period of three months to the theatres and cafés concerts in Paris to substitute the electric light for gas.

The electric light is about to be installed at the Théâtre du Gymnase, Paris, the director, M. Koening, having become convinced of the insecurity of gas.

At Madrid, the mayor has ordered the immediate introduction of the electric light in all the theatres of the city.

At Brussels, the Communal Administration has decided on the substitution of electric lights for gas in the Théâtre de la Monnaie.

Messrs. E. L. Berry and Co. inform us that Mr. Edwardes, lessee of the Gaiety Theatre, has now taken the Empire Theatre, and has placed in their hands all engineering and electric lighting arrangements. Messrs. Berry have also received instructions from Mr. H. J. Leslie to light up the new Lyric Theatre in Shaftesbury Avenue with the electric light, which will be employed all over the house, including the stage. The electric light is to be extensively used for stage effects, the limelight being entirely relegated to the limbo of things abandoned. All the latest English and foreign improvements, we are told, will be adopted.

"E. Tattersall," writing to the *Morning Post*, says: "There seems to me one simple plan which would do away with all danger of fires in theatres and the consequent panic and loss of life—that is, to use nothing but the electric light. This would do away with all danger. The Opera Comique was burnt down owing to a neglected gas burner which had been condemned, and when the gas was turned off the panic-stricken crowd were left in darkness to add to the horror and danger of the scene, and many lives were lost. Many people will not now go to the theatres —I am one of them. Something occurred long since which made me determine not to enter a theatre again, and I know others who do not go for the same reason. I therefore throw out this hint in the interest of the lessees and managers as well as of the public, and hope it may be considered worthy of attention, as the means of averting a frightful danger and of saving life."

The Enemy of Electric Lighting.—It is to be regretted that gas companies and their advocates should display the questionable taste of opposing the introduction of the electric light in theatres. At Paris, these gentlemen argue the want of room in the premises of the theatres for dynamos and motors, and the additional expense of the electric light. The former plea is overturned by the fact that the necessary force can be conveyed from a central station. As to cost, we learn that the Edison Company at Paris has signed a contract to light up the opera for the same price as was paid for gas. Some gas companies, however, are not content with arguments. At Saint Etienne, the local gas company violently opposes the Edison Company, and has entered an action against the municipality of that town for breach of contract. The Milan Gas Company has been defeated in a similar action, but has appealed from the decision of the Tribunal of Commerce.

The Electric Light at Barcelona.—The experiments which have lasted for nearly a year at Barcelona, with the view of determining the comparative merits of gas and electricity, have at last resulted in favour of the latter, consequently the Sociedad Espanola de Electricidad has obtained a contract from the municipality for the lighting by electricity of the Ramblas during a period of five years.

The United Telephone Company.—Writing to the *Financial News* "A Shareholder" says:—"As the annual general meeting of the United Telephone Company is very near at hand, I do not think it would be amiss to draw the attention of the shareholders to the fact that now is their time to demand that the £654,750 nominal value of shares in subsidiary companies be divided amongst them *pro rata*. I would suggest that every shareholder in the company should, without delay, write to the secretary and inform the board, through him, of their wishes on this point, and when they attend the meeting insist upon an affirmative or negative reply."

Harassing Telephonic Enterprise.—Recently the Western Counties and South Wales Telephone Company erected a call-room in the lobby of the Joint Companies' Railway Station at Bristol for the convenience of the 400 subscribers who are on the exchange; but the enterprise has had to be abandoned in consequence of a claim which has been made by the Postmaster-General to a monopoly of telegraphic access to the station. Surely this is carrying official interference with telephonic enterprise a little too far.

Attending Church by Telephone.—An invalid residing at Newport, Fife, says the *Dundee Advertiser*, has recently had his enforced confinement to his bedroom much enlivened by the use of the telephone. Mr. Miller, the obliging district manager of the National Telephone Company, having given the temporary use of a second instrument, it was arranged so that the invalid could communicate with anyone connected with the Dundee Exchange whenever he chose, while he could only be "rung up" at such times as he was disposed, so that he could not be disturbed when fatigued or asleep. One of the most interesting experiments he made was in listening to the services last Sunday at the West Free Church, Broughty Ferry, while lying in bed at Newport. The tolling of the church bell was easily heard. The singing of the Psalms and hymns had a delightful effect, the parts taken by different voices in the choir being easily recognised.

Spanish Telegraphs.—The Spanish Telegraph Administration asks, in the *Gaceta de Madrid*, of May 5th, for tenders for the supplying of 100,000 kilos of galvanised iron wire, for the purpose of very considerable extensions of the telegraph system.

State Control.—In arguing against the suggested State purchase of the railways, "C." in the *Morning Post* says:—"We are suffering to some little extent now for State control of telegraphs. They have never paid a farthing interest, and, having purchased exclusive rights of electrical communication, the Post Office has taken the opportunity to almost prohibit the telephone. How different it is in America where the telephone is free!"

Telegraphists' Grievances.—The Postmaster-General, replying to a memorial from the first-class telegraph clerks of the Central Telegraph Office that they might be put on a more favourable basis in regard to the service, and that their prospects might be improved, writes that, after very carefully considering their claims, and while fully recognising the good service which they render to the department, he regrets that he does not see his way to recommend to the Treasury that any alteration should be made in their pay.

The annual conference of the Telegraph Clerks' Association commenced in Belfast on Wednesday, delegates being present from Liverpool, Manchester, Leeds, Hull, Edinburgh, Bristol, and other large centres in England. The principal matter discussed was the new platform to be taken by the association in an agitation for favourable consideration by the Government of telegraphists' claims.

Spanish Telegraph Communication.—The Madrid correspondent of the *Daily Chronicle* learns that the Eastern Telegraph Company had proposed to the Spanish Government to lay telegraphic cables between Bonny, on the West Coast of Africa, and Fernando Po, Cadiz, and Tangier, and Algeciras and Ceuta, thus establishing direct communication between Spain and her possessions in the West and North of Africa. The Government, it is said, will probably accept the proposals.

Von Chauvin v. Anderson and Others.—This was an action of libel, heard on Wednesday before Mr. Baron Pollock and a special jury, in respect of a paragraph which was published in October, 1886, in the *Electrician*, a newspaper belonging to the defendants, and which it was alleged imputed fraud to the plaintiff. The defence to the action was a denial that the paragraph in question bore the meaning complained of, and the defendants further pleaded that they had published an apology and they paid 40s. into court. Mr. R. T. Reid, Q.C., and Mr. Arbuthnot appeared for the plaintiff; Mr. Finlay, Q.C., and Mr. Pollard were for the defendants. The plaintiff was the principal official in the United Kingdom of the Western Union Telegraph Company, who, besides possessing a network of telegraph wires on the American continent are also the lessees of two Atlantic cables connecting Nova Scotia with England, and the libel in question, which was headed "Telegraph Frauds," was as follows:—"Serious accusations are brought against certain of the local officials of the Western Atlantic Cable lines as to systematic tampering with or delaying Stock Exchange messages; whereby it is believed large sums have been fraudulently obtained." The plaintiff having complained of this paragraph as being utterly false, the defendants inserted an apology in their paper, the terms of which, however, were not considered satisfactory, and it was not until after the writ was issued that they published a second apology in which they acknowledged the statement to be entirely erroneous, and repeated an expression of regret which they had previously made that it should ever have caused annoyance to the plaintiff. Mr. Reid, in opening the case, having referred to the general facts, said the plaintiff would be content if this apology, which appeared so late and had not been published as the plaintiff required in the *Times* as well as the *Electrician*, should now be made in open court. Mr. Finlay said the apology was ample, and he did not see that he could add anything to it. The plaintiff was then called, but his examination had scarcely commenced when a consulation having taken place between the learned counsel at the instance of the learned judge, Mr. Finlay said it was agreed that a juror should be withdrawn. He desired to state at the same time that it was never intended to convey any imputation whatever on the plaintiff or any other English official of the company, nor did he believe that the paragraph was read by the public as intended to refer to the plaintiff. Several of the defendants were themselves interested in the plaintiff company and were obviously, therefore, the last people to wish to discredit it, and he might add that the paragraph would never have appeared at all but for the accident of the editor being absent at the time. Mr. Baron Pollock said the course that had been taken was a good illustration that unless a real charge was intended to be made the apology should be handsome and complete. Half-hearted apologies were very poor things, and sometimes tended to aggravate the original attack. He was sure a better end had been made of this case not only for the plaintiff, but for the defendants, than by any verdict which the jury might have given.

Insulation of Electric Light Conductors.—In our next issue we shall commence some papers having an important bearing upon this subject. Too little attention has hitherto been paid to the insulation of electric light leads, and this will be clearly pointed out in our series.

Gouraud v. Consolidated Telephone Construction and Maintenance Company, Limited.—This was an action, heard before Mr. Baron Pollock and a special jury in the Court of Queen's Bench on Tuesday, in which the plaintiff, Colonel Gouraud, sought to recover £1,091, the amount of his fees as director of this company from March 31st, 1883, to August 18th, 1884. The answer to the action was that Colonel Gouraud had voluntarily relinquished all claim upon the company for his fees for the period stated. Mr. Fletcher Moulton, Q.C., and Mr. Walker appeared for the plaintiff, and Mr. Finlay, Q.C., M.P., and Mr. Reginald Brown for the defendant company. Colonel Gouraud was one of the first directors of the company at the date of its formation in 1881, Sir Julius Vogel being at that time chairman of the board. After a time Colonel Gouraud resigned his seat, but was induced to rejoin the board in January, 1883. By a resolution dated April 20th, the company being then in a low financial condition, the directors agreed to forego the fees due to them for their services for the previous financial year. Sir Julius Vogel being absent from England, Colonel Gouraud was invited to become deputy-chairman of the company, and he consented to do so upon the condition that he received £1,000 per annum. This it was claimed exempted him from the conditions of the resolution. In May, 1884, a committee of investigation was appointed by the shareholders, and in consequence of the report of that committee, Colonel Gouraud in July, 1884, issued a circular addressed to the shareholders, in which he set forth the conditions upon which he became a director, but stated that no part of the £1,000 due to him had he drawn, and that he had voluntarily relinquished it. The defence relied upon this circular as an answer to the suit, and urged that the plaintiff could not have meant by the language he used in the circular mentioned to refer to any other than the £1,000 due to him for the current financial year. On the part of the plaintiff it was alleged that his relinquishment of the fees only applied to the five or six weeks previous to March 31st, 1883. After hearing evidence on both sides the jury gave a verdict for the amount claimed, minus the amount paid into court.

Jarman's Electric Tramcar.—We observe that on Monday afternoon a demonstration of the capacities of this tramcar was given at the Electric works, Electric Lane, Atlantic Road, Brixton. A line of rails had been laid down especially calculated to try the capacity of any mechanical motive power—an incline of 1 in 40 and a very nasty curve of 43 feet radius. The ascent was stated to be as high as that of Brixton Hill, and the curve sharper than would be laid down for ordinary traffic. The car weighed about five tons and a quarter, when loaded with the electric motor, storage cells, &c. The vehicle was an old one, which has done duty of the southern lines of tramways. Its present motive power is 70 E.P.S. storage batteries placed under the seats. These drive an electric motor fitted with two armatures, such as we described in our issue of October 29th, 1886. Amongst the experiments on Monday was the getting up of full speed in a few yards, and then stopping when going eight miles an hour in a space of 6 feet.

The Institution of Civil Engineers.—A Telford Premium has been awarded by the Council of the Institution of Civil Engineers to Mr. Killingworth Hedges for his paper on Central Station Lighting.

Telephonic Enterprise at Bristol.—Messrs. Stubbs and Co. have recently placed their Trade Protection Offices at Bristol into telephonic communication with their sub-offices at Newport and Cardiff, the work having been carried out by the Western Counties and South Wales Telephone Company. The total length of wire used is 67 miles, and it is stated that talking can be carried on with the utmost ease. Messrs. Stubbs are contemplating joining Swansea with their Bristol establishment.

Our Columns.—Several of our articles this week are specially interesting. For instance, the continuation of Mr. Swinburne's Practical Electrical Measurement; the description of Sir William Thomson's instruments; Repairing incandescent lamps; Swinton's telephone; and Prof. Elihu Thomson's discourse upon alternating currents. Mr. Sumpner's very elaborate paper, which contains nearly thirty diagrams, will be concluded in our next, and although some of the figures are alluded to incidentally in that portion which we now publish, the description of each diagram commences from the place at which we have divided the paper.

Elieson's Electric Locomotives.—As we notified would be the case last week Mr. Elieson commenced operations on the North Metropolitan Tramway Company's line on Monday last with two cars, and during the day carried about 1,700 passengers. Several little mishaps have since occurred which could not have been foreseen, but they do not affect the general principle of the system and can easily be overcome in the course of a few days and a recurrence prevented. The running is still continued every day, but with one car only; still, sufficient has been accomplished to show that our prognostications respecting this system are in a fair way of being fulfilled, and to Mr. Elieson we offer our sincere congratulations.

Electricity in the Royal Navy.—The paddle steamer *Helicon*, which is to be commissioned for service as despatch vessel to the Channel Squadron, has been docked at Sheerness for the purpose of being overhauled and of being fitted with electric search lights.

The Royal Institution.—Mr. James Staats Forbes, Mr. John Isaac Thornycroft, M.Inst. C.E., Mr. John Mowlem Burt, Mr. Hugh Gordon, B.A., and Mr. Douglas Hankey, have been elected members of this institution.

The South Kensington Museum.—The interesting historical collection of telegraphic apparatus in the South Kensington Museum is in course of rearrangement and re-catalogueing by Mr. H. R. Kempe.

Electric Safety Lamp for Miners.—The Lord Provost of Glasgow, at a public meeting called to raise funds for the Udston Mine disaster, exhibited Pitkin's electric lamp for miners. Mr. Pitkin's apparatus has already been illustrated in our columns.

Dynamos Wanted.—It is stated that the Admiralty is asking for tenders for a large number of new dynamos for ship lighting. We trust that the report is true.

Royal Society's Soirée.—This annual gathering was held on Wednesday evening. Amongst the interesting features introduced was the connection of Edison's loud-speaking telephone receiver with the Brighton telephone exchange, where airs were played on the cornet and rendered plainly audible in the apartments of the society in Burlington House. Dozens of the United Telephone Company's ordinary instruments were also laid on to the performance of "Ruddigore" at the Savoy Theatre, and gave great delight to many scores of listeners, by whom the singing on the stage and the playing by the orchestra were heard with excellent effect. Remarkable electrical phosphorescent effects, produced *in vacuo* by Mr. Crookes, were made more than usually interesting by being performed on diamonds, rubies, and other precious jewels contributed by Mr. Streeter. Dr. Sclater sent one of the very fine electric eels from the Zoological Society's Gardens, and those who liked were at liberty to experience the shocks of this singular fish, but not many availed themselves of the opportunity.

Prof. Tyndall's Retirement.—Prof. Tyndall, on his retirement from the chair of National Philosophy in the Royal Institution, has been invited to a complimentary dinner at Willis's Rooms on the 29th inst. The President of the Royal Society will take the chair.

The New York Electric Club. — The Board of Managers of the Electric Club is talking of constructing a club house in New York City. The matter has been canvassed several months past by the officers of the club, and the expression of opinion from leading electrical representatives has been decidedly favourable. The club house, as planned, will comprise departments to aid in educating beginners in the interesting study of electricity, in developing the science, and ncreasing electrical sociability. A course of free lectures in the Assembly Rooms has been favourably considered, also complete laboratory, electrical library, rooms for out of town visitors, &c., in fact, the construction of an edifice in New York City that will comprise comprehensive electrical headquarters where representatives of all electrical interests can assemble and be at home.

The Marchant Engine.—In the London Bankruptcy Court on Monday, the case of Mr. R. M. Marchant came before the Official Receiver. The debtor, late of High Holborn, civil engineer, has furnished accounts under a receiving order, made on the 6th ult., showing liabilities to the amount of £5,783, and assets £3,675. He states that from 1869 to 1884 he was engaged in the perfecting and patenting of certain inventions; that in the latter year he sold certain engine patents for £2,500, but that such sale was afterwards cancelled, and a syndicate formed, which was registered as the "Marchant Engine Syndicate, Limited." He attributes his failure to his inability to sell 2,000 fully paid £5 shares possessed by him in the Marchant Engine Syndicate, owing, he considers, to the failure of arrangements for the exhibition of a completed engine. The debtor has, by consent, been adjudged bankrupt.

New Book.—Messrs. Longmans will shortly publish "Electricity for Public Schools and Colleges," by W. Lorden.

Propelling Small Boats.—Mr. Alexander M'Rae, an engineer of Greenock, some months ago patented an invention for the propulsion of small boats according to a method and by the aid of a mechanism which demands a minimum of motive power, and has since brought the machinery to considerably greater perfection. The boats are propelled by the power from feet or hands, but it is the intention of the inventor to introduce electricity into the boats, for which the machinery is said to be peculiarly adapted.

Electrical Tramway Gear.—An important patent, No. 2,765, 22nd February, 1887, by Mr. W. H. Knight, of Boston, America, has just been published. There are, we think, many points in the gearing described which are worth the study of those interested in the subject of electrical tramways.

The Measurement of Alternating Currents. — In patent No. 4,027, 17th March, 1887, Messrs. R. Dick and Rankin Kennedy describe a simple method of enabling alternating currents, varying in intensity from ·1 to 10,000 volts potential, to be measured. This is effected by means of transformers, the latter being used to obtain a measurable potential on the instruments available for making the measurements.

Electric Lighting Tenders.—The *Contract Journal* contains the following notice :—For placing in thorough repair and working order the electric lighting installation at the Royal Pavilion, and performing certain other works in connection therewith. Specification may be seen and forms of tender obtained at the office of the borough surveyor, Mr. P. C. Lockwood, C.E., Town Hall, Brighton. Sealed tenders, addressed to the Pavilion Committee, and endorsed "Tender for Repairs to Electric Lighting Installation," must be left at the office of Mr. F. J. Tillstone, town clerk, Town Hall, Brighton, before 10 a.m. on 13th inst.

The Loss of the "Volta." — The Wreck Commissioner, Mr. H. C. Rothery, opened an inquiry on Monday at the Westminster Town Hall into the circumstances attending the loss of the *Volta*, of London, on April 18th last, in the Greek Archipelago, the wreck being attended by the loss of the lives of the master and 11 of the crew.

American Electrical Papers.—The last issue of our very energetic and estimable contemporary, the New York *Electrical World*, was full to repletion of the doings of the American Institute of Electrical Engineers. We shall hope to again reproduce next week one if not more of the papers read before that society, and we may probably have something to say upon one of the subjects treated.

Repairing Incandescent Lamps.—The method of repairing glow lamps devised by M. Pauthonnier, which we describe this week, does not appear to us to possess the value claimed for it by our French contemporary. It would cost more to patch up a lamp than to make a new one, and opening a bulb and sealing it up would more or less spoil its appearance; besides, the resistance of the carbon would be altered. Most broken lamps are blackened, and in any case this joining process would blacken the bulbs. Mending a carbon cannot give, at least such is our opinion, the marvellous new properties mentioned.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Domestic Battery Syndicate, Limited.—An agreement of 26th ult. provides for the purchase by this company of the Letters Patent to be granted for the invention of Charles Edward O'Keenan, of 21, Boulevard de Versailles, St. Cloud, electrician, relating to certain processes for improvements in primary galvanic batteries (Provisional protection No. 11,834, dated 17th September, 1886). The purchase consideration is £5,000, payable £1,000 in cash and £4,000 in fully-paid shares. The vendor to the company is Mr. John Shedlock, C.E., of 9, Gracechurch Street.

Gülcher Electric Light and Power Company, Limited.—At an extraordinary meeting of this company, held at Cannon Street Hotel on 12th ult., it was resolved to wind up voluntarily, and Mr. Daniel de Castro was appointed liquidator with authority to consent to the registration of a new company with the same title. It was also resolved that the remuneration of the liquidator be £210. The resolutions were confirmed on the 27th ult. and duly registered 2nd inst.

Schmidt-Douglas Electric Company, Limited.—An agreement of 21st April, filed on the 6th inst., provides for the purchase of the business of electrical engineers, contractors and manufacturing electricians carried on by F. T. Schmidt and R. C. Douglas, of Hustlergate, Bradford, for £3,500 cash and £3,500 in fully paid shares.

Woodhouse and Rawson Electric Supply Company, Limited.—The annual return of this company made up to the 19th ult. was filed on the 1st inst. The nominal capital is £100,000 in £10 shares. 2,007 shares have been taken up and are fully paid.

Railway and Electric Appliances Company, Limited.—The annual return of this company made up to the 4th ult. was filed on the 26th ult. The nominal capital is £500,000 in £1 shares. 130,201 shares have been allotted, including 1,100 shares held by persons whose names have been struck off the register by order of the Court and 58,550 shares surrendered. Upon 48,001 shares the sum of 15s. per share has been called, the remaining 22,550 shares being considered fully paid. The calls paid amount to £34,977 10s. and unpaid to £1,023 5s. Upon the surrendered shares the sum of £59,600 had been paid.

Akester Electro-Motor and Accumulator Company, Limited.—The registered office of this company is at 58, Crompton Street, Goswell Road, E.C.

Automatic Electrical Apparatus Company, Limited. The registered office of this company is at 47, Cannon Street, E.C.

NEW COMPANIES REGISTERED.

Westinghouse Engine Company, Limited.—Nominal capital, £100,000 in £10 shares. Objects: To manufacture and deal in Westinghouse and other steam engines, machinery, and electrical apparatus, and to carry on business as mechanical and electrical engineers. Signatories (with one share each), *J. M. Stobart, Ryde, I.W.; N. Duff Bruce, 8, Champion Park, Denmark Hill; *J. W. H. James, C.E., 9, Victoria Chambers, S.W.; *Sir J. D. Mackenzie, Bart., 62, Redcliffe Square; *J. A. Machellan, C.E., Glasgow; J. Dixon Gibbs, 18, Warwick Street, Regent Street; J. Edwards, 152, Holborn Viaduct. The signatories denoted by an asterisk are the first directors; qualification, £250 in shares or stock; remuneration, £800 per annum. Registered 6th inst. by Wynne, Holme and Wynne, 40, Chancery Lane.

CITY NOTES, REPORTS, MEETINGS, &c.

Consolidated Telephone Construction and Maintenance Company, Limited.

THE sixth annual general meeting of the shareholders of this company was held at the Cannon Street Hotel on Thursday, the 2nd inst., Mr. C. L. W. Fitzgerald, chairman of the company, presiding.

Mr. Charles Curtoys, secretary, having read the notice convening the meeting, and the directors' report having been taken as read,

The Chairman said he rose to address the shareholders with considerable satisfaction, for an event had happened which placed them in a position to do something a little out of the common, and that was the amalgamation of the River Plate Telephone and Electric Light Company with its opponent, the United Telephone Company of the River Plate. As a consequence of this amalgamation the shares in the late River Plate Company had ceased to exist. They had received a large sum—no less than £10,277—which the River Plate Company had owed them, and also £1,250 as a compromise of the contract which that company had failed to fulfil for the supply of telephones. Further, the dividend of 9 per cent. cumulative, amounting to £1,838 17s. 10d. had been paid them, and an amount standing in their books at £9,256 had now been converted into £8,985 in shares of the United River Plate Telephone Company, at par, and £11,564 in cash had also been received. There was also a very considerable sum of money to be received from this amalgamation. Of course it was very difficult to know how much was likely to accrue, but he thought, roughly speaking, he might put it down at somewhere about £8,000, perhaps more, but it depended very much upon how the business at the River Plate was liquidated, in other words, upon whether they got a good price for the assets which they held over there. This £11,564 having come to them, so to speak, from the sale of the shares which they held in the River Plate Company, the directors were in the position that they had a sum of money which they did not know what to do with, and, with the consent of the auditors, they came to the conclusion that it would be much better to hand that money back to the shareholders in the form of a shilling per share, reducing the capital by the like amount. He would explain that by pointing out that they had got against capital expenditure, goodwill, and patent rights, £87,000; this they were going to reduce at once by £11,564, which, of course, to a certain extent placed their business in a better position, in so far that they would be able to pay bigger dividends on the lesser amount of capital which they would have to deal with in the future, the shareholders in the meanwhile getting the 1s. per share back into their own pockets. He thought that should be a very satisfactory arrangement to the shareholders. There seemed to be some confusion existing in certain shareholders' minds about this reduction of capital; they seemed to confuse it with the 5s. per share reduction of capital, which was a sum lost by the late management. Now this was a sum of money which they were, so to speak, absolutely going to pay the shareholders, not going to take away from them. There was a great deal of difference, he thought, in a reduction of 5s., getting nothing for it, and getting 1s. paid back. To carry out that arrangement it would be necessary to hold an extraordinary general meeting at the conclusion of the meeting then proceeding, after which they would go to the Court to obtain the necessary powers to pay back the 1s. The board had decided to exhibit telephones at the Brussels Exhibition, and he was happy to say that on all hands, in the Belgian and other papers, it was admitted that their instruments were absolutely of the first class. The only thing he wished to say further about that matter was that abroad, unfortunately, people wanted things cheap; they did not care for a high-class instrument, and it was a very difficult thing to do to make a cheap instrument which could really be called first-class. However, they hoped for beneficial results from the exhibition; in fact, it had already led to numerous inquiries from various places. The directors at the last meeting asked their permission to join with the Edison-Gower-Bell Telephone Company in prosecuting infringers in Belgium. So far, they had obtained the permission of the courts to bring their action, which, of course, was a great step. They had now got to prove that their patent was the master patent covering the telephones used in Belgium. The trial would take place shortly, and he need not remark that everything was being put in their way; their opponents had not helped them at all—had, indeed, stopped them as much as they could by putting down an enormous sum as damage which they alleged they would sustain through not being able to use the telephone, and one thing and another. But everything up to the present had gone favourably for the company, and the Belgian business was a source of profit which might astonish them some day. The next point he wished to allude to was the fact that they at one time had certain machinery in the factory which did not belong to them. That was a very unsatisfactory position to be in, because something might have happened at a moment's notice that would have taken that machinery away; and, the opportunity having occurred, the directors thought it would be the best to buy that machinery at once, so that it all belonged to the company now, and they were, he should think, in as perfect a position for manufacturing purposes as they possibly could be. He thought they would all approve of that course; he thought it was a very wise step to have taken. Their subsidiary companies were steadily improving. This was very satisfactory, because it led them to believe that sooner or later those companies would be a great support to them. The Telephone Company of Austria and the Edison-Gower-Bell Telephone Company had increased no less than 683 in the number of their subscribers, with an annual rental of £4,402. It was with very sincere regret that the directors had to announce the death of one of their colleagues. Mr. John Taylor was a man of exceptional ability and of great business capacity. He rendered them great service, and he died absolutely in harness, for he was at a board meeting one day, and the next they heard of him was that he had dropped down dead in the street. They all regretted his death very much. Major Fitzgerald and Mr. Bateman had retired from the board to take their seats on the United board. The thanks of the company were due to those gentlemen for leaving the company, for they had gone on to the board of the United Company to look after the interests of this company. The figures for the year showed a net profit of £8,957 4s. 4d., which, with the amount carried forward, left a balance of £10,127 8s. 6d. They proposed to deal with this by paying a further dividend of £2 10s. per cent., which would make, with the interim dividend paid in November last, 5 per cent. for the year. They had further written off £558 in depreciation of plant and machinery and furniture; £1,695 18s. 5d. being thus left to be carried forward. They had kept their stock down, and it now stood at £3,658 12s. 1d., and he was happy to state that though this was principally due to the River Plate Company having paid them £10,000 odd, the amount of money owed them was not quite so gigantic as usual. The total amount owing was £8,144 15s. 8d., of which they had reserved £1,487 14s. 1d., as against the possible non-receipt of the money. There was one other matter he should like to allude to. The Edison-Gower-Bell Telephone Company's 20,000 preference shares of £1 each and the 15,000 ordinary shares of £1 each had been reduced in value; in other words, they had written down that value by, roughly speaking, £4,000, thereby really placing that security on a more satisfactory footing to be dealt with at some future date. He was also happy to state that the United River Plate Company's shares, of which they held 1,797, were now quoted on the Stock Exchange, and were a marketable security standing at a premium. That, he thought, was cause for congratulation amongst the shareholders. The Telephone Company of Austria, of which they held £34,500 debentures at par, had paid its interest regularly, and was now in a position to state that it was really earning a dividend, of which they would no doubt obtain the benefit.

A Shareholder: Is the River Plate Company going to be a customer of ours?

The Chairman: I hope so; but we are now in the position that it is an open market, so to speak.

A second Shareholder enquired whether the United Telephone Company took all its instruments from this company, or whether the directors were aware that they took some from abroad.

The Chairman: We think they take all the instruments from us; we have no reason to suppose otherwise, or you may depend upon it we should very soon want to know the reason.

A Shareholder, referring to the accounts, asked if they had £120,000 and upwards invested in Austria.

The Chairman: No, sir. That, you will see, is simply a *contra* item on one side of the accounts. It is the Austrian capital. But I should explain to you that by Austrian law that company is not allowed to work, but the Consolidated Company is working Austria for the other company, and we are in this position there that we are now applying to the courts to enable the telephone company of Austria to work the business in the place of the

Consolidated. It is perfectly independent; but you will see it does not come to anything. It might be left out, but by Austrian law we are obliged to put it in the balance sheet.

A Shareholder: Is there any liability attached to it?

The Chairman: None whatsoever. Replying to further questions, the Chairman said that the explanation of the £174,000 in the Edison-Gower-Bell Company represented shares of that Company held by the Consolidated Company. Those shares were a growing asset, just as were the £28,000 in the Telephone Company of Austria. They were improving in value every day, but what their present value was he could not say.

A Shareholder: Why are they not included as an asset?

The Chairman: Because they are against the £87,000 capital expenditure. They will become an asset some day I hope, and pay us dividend. I shall be very much mistaken if they do not.

Mr. J. G. Griffiths, the auditor, said the reason why the shares referred to were not valued, was that they were practically of an inassessable value at the present moment, and it would be impossible, he should think, for the directors—certainly it would be impossible for the auditors—to say exactly what those shares were worth, and if they put them at a valuation now it would be a purely guess valuation, and they would have to vary them from time to time, and thus affect the appearance of the balance sheet without affecting their position in any respect whatever. The directors would, no doubt, hold those assets in view, and as they were realised, apply the proceeds to the reduction of the expenditure, and when that figure was disposed of, as it would be eventually, then the balance would be a profit to the company, but not before.

The Chairman then proposed that the statement and accounts and balance sheet and the report of the directors as submitted be received and adopted, and that a final dividend of 2½ per cent. be paid, making with the interim dividend previously paid, 5 per cent. for the year ended March 31st, 1887,

Sir Alexander Armstrong seconded the motion.

The Chairman and Mr. Van Zeller, the retiring directors, and Mr. J. G. Griffiths, the auditor, were re-elected.

The meeting having been re-constituted as an extraordinary general meeting,

The Chairman said he had already explained what the proposed reduction of capital meant, and he would therefore simply move, "That the capital of the company be reduced from £243,787 10s., divided into 224,850 shares of 15s. each, and 75,150 shares of £1 each, to £232,545, divided into 224,850 shares of 14s. each and 75,150 shares of £1 each, and that such reduction be effected by returning to the holders of the 224,850 shares that have been issued paid up capital to the extent of 1s. per share, and by reducing the nominal amount of such 224,850 shares to 14s. each."

Sir Alexander Armstrong seconded.

A Shareholder: I presume from the fact of your proposing this reduction that you do not look forward to such an enormous business as to be able to employ the money.

The Chairman: We find we cannot use the money.

A Shareholder: Has not this company some claim against Sir Julius Vogel?

The Chairman: Yes, sir; but it is a difficult thing attacking a gentleman in Australia [? New Zealand]. If he were to come over to this country we should probably take some steps against him.

The motion was then put and carried unanimously, and a vote of thanks having been accorded the directors, the meeting closed.

Hastings Electric Light Company, Limited.

ON Tuesday Mr. H. M. Baker presided at the ordinary general meeting of the above company, when the annual report of the directors showed that the company has now, on three circuits, 30 arc lamps and 704 incandescent lamps, as against 27 arc and 576 incandescent lamps in the corresponding period of last year, there having been a steady increase of business. The sum of £3,186 8s. 7d., the amount given up by the liquidator of the Hammond Electric Light and Power Supply Company, has been placed to the reserve account, to meet depreciation of plant and machinery. The revenue account shows a gross profit of £248 9s. 10d. on the total receipts of £1,835 11s. 4d. Against this, however, must be charged the amount paid for interest on bank over-draft and loan, viz., £247 4s. 7d., thus leaving a net profit of £1 5s. 3d. The directors considered that a determined effort should now be made to pay off the over-draft, and to raise a further sum of money sufficient to enable them to extend their operations. They suggested the raising of £5,000 by debenture bonds.

The Chairman moved the adoption of the report, remarking that it had become necessary to raise £5,000 by debenture bonds, but outside the directors, only one shareholder had promised to invest £200. The directors felt very strongly that, besides investing their money, they were spending much time and expending a good deal of anxious thought on the business, and although they did not wish to find fault, they thought that they might have received a little more support from the inhabitants. But for a few spirited individuals, Hastings would be hopelessly in the background. The directors regretted that they were unable to give the shareholders a dividend, because they felt that they deserved it. Under present circumstances, it would be for the shareholders to consider, at a future meeting, what had best be done.

Mr. J. Reeves, jun., seconded the adoption of the report.

Mr. F. A. Langham said that unless the shareholders came to the rescue, he was an advocate for stopping the further progress of the company. The shareholders knew very well that there was a demand for the electric light, and that if they could only extend their operations, they would get more custom. Their engines and machinery had cost £14,000, and if they scraped on as they had been doing of late, the plant would depreciate in value and they would be in a worse position to wind up the company than they were at the present time. If they could raise the £5,000 required, they might double their profits and pay a dividend of five per cent.

The report was then adopted and Messrs. Parsons and Noakes were re-elected directors.

The Chairman intimated that an extraordinary meeting of shareholders would be called.

Eastern Extension, Australasia and China Telegraph Company, Limited.—The directors have declared an interim dividend for the quarter ended March 31st, of 2s. 6d. per share. The coupon on the 5 per cent. Australian Government Subsidy Debentures, due on July 1st, will be paid on and after that date at Messrs. Barclay, Bevan and Co.'s bank. Coupons must be left three clear days for examination.

Brazilian Submarine Telegraph Company, Limited.—The directors have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended 31st March last, and payable on the 24th inst. The books of the company will be closed from the 16th to the 23rd inst., both days inclusive.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of May was 4,040, estimated to produce £3,030, against 3,744 messages, producing £3,103 in the corresponding month of last year. The receipts for the month of February, estimated at £3,000, realised £3,009.

The Great Northern Telegraph Company, Limited. The receipts for May, 1887, £22,000; January 1st to May 31st, 1887, £103,320; corresponding months, 1886, £100,900; and of 1885, £118,000.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending June 3rd were £3,618, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st May are £3,361, as compared with £2,996 in the corresponding period of 1886.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of May were £1,557, against £1,709 in the corresponding period of last year.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending June 3rd amounted to £4,473.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending 31st May are £4,800.

NEW PATENTS—1887.

7934. "Switch." A. B. GILL. Dated June 1.

7950. "Telephones for indicating and recording the number of times that a telephonic instrument is used." D. J. SMITH, H. F. JACKSON. Dated June 1.

7953. "Electric signalling apparatus." G. CONZ. Dated June 1. (*Complete.*)

7975. "Secondary batteries or accumulators." L. C. E. LEBIEZ. Dated June 2.

7982. "Telephonic instruments for enabling them to be used only on prepayment for such use." C. L. W. FITZGERALD. Dated June 2.

8046. "Electric meter." P. JOLIN. Dated June 3.

8059. "Electric arc lamps." F. C. PHILLIPS, H. E. HARRISON. Dated June 4.

8068. "Holder or socket for electric incandescent loop lamps." H. BAYLEY. Dated June 4.

8076. "Holders for incandescent lamps." R. T. TURNBULL. Dated June 4.

8086. "Cable sleeves." J. G. LORRAIN. Dated June 4.

8088. "Electric alarm devices." A. ZETTLER. Dated June 4.

8126. "Chlorine batteries." P. A. FICHET, A. NODON. Dated June 6. (*Complete.*)

8141. "Electric arc lamps." M. E. DOMON. Dated June 6.

8145. "Galvanic batteries." D. SKRIVANOW. Dated June 6.

8159. "Effecting electric telegraphic communication applicable specially for telegraphing to lighthouses, &c." W. SMITH. Dated June 7.

8181. "Testing submarine electric telegraph cables." H. A. TAYLOR. Dated June 7.

8206. "Effecting by insertion of a coin the production of electric light for a certain time." D. H. DAVIES, J. M. TOURTEL. Dated June 7.

8240. "Electrical apparatus, more particularly in battery cells, adapted for use in medico-electrical apparatus." J. R. HARD, T. WILSON. Dated June 8. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

5168. "Improvements connected with the electric lighting of trains." R. E. B. CROMPTON and J. SWINBURNE. Dated April 14. Relates to the apparatus already described in the REVIEW.

5381. "Improvements in electrical contact apparatus." A. DE KHOTINSKY. Dated April 17. 8d. Claim:—In electrical contact apparatus subdividing the conductors, which are brought in contact into several thicknesses so as to multiply the contact surfaces, substantially as and for the purposes set forth.

6586. "Improvements in apparatus for lighting railway trains by electricity." T. P. CARSWELL. Dated May 17. 8d. Any carriage which it is desired to light by electricity on a particular railway is fitted with one or more incandescent or other suitable electric lamps, and with the necessary insulated conductors for the electric current. One of the conductors is put in electric connection with one or more of the axles of the carriage; and the other conductor is connected to a contact roller, arranged so as at the required times to run on a special rail laid in an insulated manner between the two ordinary rails. One or both of the ordinary rails is or are electrically connected to one pole of a stationary dynamo machine or other source of electricity, and the insulated middle rail is electrically connected to the other pole, the apparatus being worked or arranged so that a current can pass whenever contact is made by the contact roller. Claims:—1. The combining of parts of apparatus for lighting a railway train by electricity, substantially in the manner described. 2. The system of arranging apparatus for lighting a railway train by electricity wherein the electric current obtained from a stationary source is communicated through a special conductor rail and through contact rollers fitted to the several carriages or to some of them, each carriage being independently supplied with current, substantially as described.

6604. "An improved form of galvanic cell for bell ringing and other purposes." G. H. BAYS. Dated May 17. 4d. The electrodes are a rod or plate of zinc, the surface of which is amalgamated with mercury and broken gas retort carbon, with or without the addition of oxide of manganese or other solid depolariser. The liquid is dilute sulphuric acid or other acid or alkali, other than chloride of ammonium. The inventor arranges the broken carbon around the outside of a porous jar of earthenware or other material, and inside a jar of stoneware or other non-porous material. He places the amalgamated zinc rod or plate in the porous jar, and it is held in the centre thereof by a copper wire which is fastened to one end of the zinc rod or plate, and passes through the centre of a cover composed of wood, ebonite, or other insulating material, and fitting on the top of the porous jar. This wire forms the negative pole of the cell. A carbon rod passes down through the broken carbon, and acts as a conductor—a screw being fastened to the upper end thereof, forms the positive pole of the cell. The space between the top of the porous jar and the outer jar is sealed with a compound of pitch and resin, or other similar substance, a hole being left for the admission of air. Claims:—1. A rod or plate of amalgamated zinc, as used in combination with the materials and substances, substantially as described. 2. A cover of insulating material, as used in combination with the materials and substances, substantially as described. 3. The combination and arrangement of materials and substances substantially as described, namely, a positive electrode of amalgamated zinc, fixed centrally by means of a cover of insulating material; and a negative electrode of broken carbon, disposed around and separated from the zinc by means of a porous jar, and the whole enclosed in a containing vessel.

6866. "Improvements in metallic telegraph poles, and poles and posts for various purposes." J. C. JOHNSON. Dated May 21. 8d. Claim:—The construction and combination of the parts described and represented in the drawings for supporting the upper hollow or tubular part of the pole or post in the lower hollow or tubular part or base, and for connecting the two parts together, or for connecting together the several hollow or tubular parts of which the pole or post may be composed, as described and illustrated in the drawings; that is to say, making in the upper part of the base or larger part of the pole or post an internal horizontal shoulder for supporting the bottom of the upper or smaller part of the pole or post, and making the inside of the upper part of the base or larger part taper for receiving a taper, divided ring, or annular wedge by which the two parts of the pole or post are fixed together, substantially as described and illustrated.

9518. "Improvements in the manufacture of carbon electrodes." R. APPLEGARTH. Dated July 22. 8d. Claim:—The manufacture of carbon electrodes with corrugations, undulations, indentations, or other irregularities on the inside, to obtain increase of surface exposed to the acid or exciting medium, as described with reference to the drawings.

9582. "Improvements in dynamo-electric machines." J. P. HALL. Dated July 24. 11d. Claims:—1. In a dynamo-electric machine the magnet cast in one piece with the bedplate, substantially as described. 2. In a dynamo-electric machine the magnet and also standards for the pedestals or bearings of the armature shaft cast in one piece with the bedplate, substantially as described. 3. The general construction, combination, and arrangement of parts, substantially as set forth.

10800. "Improvements in the process of and apparatus for manufacturing carbons for electric lamps." J. T. LISTER. Dated August 24. 1s. 1d. The claims in this specification are 38 in number.

13592. "Improvements in primary batteries." M. B. HOLLIES. Dated October 23. 8d. Claims:—1st. In a primary battery, the employment and use of a porous cell of suitable electrical resistance filled with a mixture of natural plumbago, and nitric, or oxacid. A rod, stick, or tube of carbon being inserted therein, substantially as described, and for the purposes set forth. 2nd. The combination of a porous cell, or pot filled with a mixture of natural plumbago and nitric acid, or oxacid, with a rod, stick or tube of carbon embedded in same. Said tube being filled with nitric acid, or oxacid, from time to time for the purpose of maintaining the full energy of the cell, without removing same, as set forth. 3rd. In a primary battery the combination and use of the element zinc, with a porous cell, or pot, filled with a paste formed of natural plumbago, and nitric, or oxacid, and having a rod, stick, or tube of carbon embedded therein, the zinc and cell, or porous pot, being placed in an outer cell, consisting of stoneware, or other jar or trough filled with plain water, as described, and for the purposes set forth.

14937. "An improved method of preventing the escape of noxious fumes from batteries used for electrical purposes." M. BAILEY and J. WARNER. Dated November 17. 8d. Consists in sealing up the internal pot, with pitch, paraffin, or other suitable substance, a small hole being formed in the pitch or paraffin for the insertion of a thin glass tube, or this tube may be inserted in an India-rubber or wooden plug which is embedded in the pitch as described. The tube being fused into a glass cylinder which may be of any convenient size is cut off a little below the top of same. A glass tube rounded and sealed at one end is loosely fitted into this cylinder in an inverted position, and water or other fluid poured in so as to form an effectual luting. The action is as follows:—Any gases resulting from the exciting, oxidising or depolarising materials contained in the porous, or internal pot, pass up the small tube fastened into the same, and are collected in the inverted bell shaped tube, which acts as an ordinary gasometer, the escape of any noxious fumes being prevented by the water or other fluid luting as described. The claims are 5 in number.

CORRESPONDENCE.

Photometry.

You lately gave a description of the Vernon Harcourt Standard Pentane Lamp as manufactured by the Woodhouse and Rawson Manufacturing Company at Hammersmith.

Experiments have lately been made with a view to rendering continuous photometry with the lamp more simple. These experiments have shown that by the employment of a tubular "cut-off" for the flame, the light emitted by the portion below the "cut-off" is perfectly constant, although the height of the flame may vary within considerable limits. This is founded upon a well-known fact that the extra light produced in the upper portion of the flame is counterbalanced by the increase of the non-luminous portion below.

Careful experiments show that no perceptible difference can be detected in the value of the light, although the difference in the height of the flame would produce 12 per cent. difference in the total value of the naked flame.

Although the method employed is not recommended as being of such absolute accuracy as when the flame is measured by its just touching the platinum wire, yet the results obtained have been very remarkable, and there is not to be found the slightest difficulty in maintaining the flame within a range of 6 mm. for an indefinite length of time.

The tubular "cut-off" is attached by a small clamp to the movable scale, and can, therefore, be set at the exact height by means of the scale, and two small square openings in the tube enable an operator at any time to see whether the top of the flame is within the limits of the aperture.

The value of the light with different heights of "cut-off" has also been determined within convenient

limits, so that this method can be employed for photometry by means of variation of the standard light.

Experimenta.

June 2nd, 1887.

Secondary Generators.

Alongside of M. Gaulard's letter in yours of 3rd June, appears a letter in your contemporary, the *Electrician*, by M. Leib, regarding the Turin electrical distribution by alternating currents and transformers. Your readers should study the two letters together. One is tempted to remark in the face of such reports, that M. Gaulard's time and money might be more profitably employed in perfecting his appliances than in litigation. That, however, is his own affair and his threatening me is quite a matter of course. Unfortunately I cannot threaten him with infringement, for the simple and significant reason that I cannot discover any dangerously successful installation of his in any country in which I hold patent rights.

Perhaps you can inform me as to how the distribution of electric lighting by alternating currents and transformers succeeds in London? Is there a Gaulard and Gibbs system in operation in that village? Whose system is in use in the Grosvenor Gallery?

M. Gaulard is mistaken in his supposition that this is a scientific discussion. I treat the subject from the view of the claims set up by the various inventors; a very matter of fact affair, as may be found by a perusal of specifications.

Rankin Kennedy.

June 6th, 1887.

Regulation of Series Tranformers.

We have received from Mr. Rankin Kennedy the following copy of a letter which he has addressed to the editor of the *Electrician*:—

The interesting notices of Messrs. Sharp and Kent's regulation of series transformers do not contain any actual practical results of careful tests to ascertain the losses in the "choking coils." The figures in the fifth column are calculated from $C^2 R$, which is not applicable in the case of a choking coil; these figures obtained thus are no doubt nearly correct, and the difference between these figures and the correct figures may be too small for consideration when only one coil is employed, but in a distribution system where, perhaps, 1,000 coils might be in use, a small difference in each becomes a large difference on the whole number, and would materially affect the economy.

The opposition to the current which a rapidly alternating E.M.F. tends to send through a choking coil is made up of three factors:—

1. Ohmic resistance.
2. Apparent resistance, due to rapidity of alternations preventing the current from reaching a steady value distribution over the section of the conductor; this apparent resistance is the same for a wire wound into a coil, laid out straight or bent back on itself.
3. "Impedence" due to self-induction, or rather the induction of the convolutions of the coils of wire on each other, the value of which depends on the shape of the coil, and also on the form, size, and quality of the core of iron upon which choking coils are always wound.

This core in all coils becomes hot, proving that currents are generated in it; by excessive lamination or subdivision this heating can be reduced to a minimum, but still it is always there, and the energy expended in heating this core cannot be found, and is not accounted for by the $C^2 R$ formula.

In a transformer, $C^2 R + C_s^2 R_s$ gives the energy expended in the transformer conductor and secondary circuit, where C is primary current and R primary ohmic resistance, C_s secondary current, and R_s secondary resistance, including lamps, leads, &c.; but to find the total energy expended we must find the energy expended in the core in addition to the above. We cannot measure the C and R in the core, but we can measure the energy expended in it by measuring the heat generated per minute or hour in it; in an actual test of this kind, with a pressure of 1,200 volts, a resistance in the coil of 5 ohms, a current of 0·18 ampères was found, while the total energy expended in heat was equivalent to some 270 watts, a figure agreeing neither with $C^2 R$ nor $E \times C$; a similar result was published by Messrs. Zipernowski & Co., who found nearly 400 watts expended in a resistance under 5 ohms, with a current of 0·17 ampères, the pressures being over 1,900 volts.

Until we get methods of measuring alternating pressures and currents, calculations like the tables given are not to be taken as anything but approximations.

Mr. Elihu Thomson and Messrs. Sharp and Kent may refer to a patent of Dr. Hopkinson dated 1881, No. 3,362, and to various works by Gordon for early applications of choking coils in place of resistances and in place of lamps.

I referred to Dr. Hopkinson's coils in a letter to the ELECTRICAL REVIEW of 1883, and mentioned their great value as not absorbing energy like ordinary resistances. Sir William Thomson pointed out their value to me as regulators early in that year, and instanced Dr. Hopkinson's work in a conversation which I had the honour to be present at, the subject being induction coils and self-induction.

Lastly, I may be permitted to express an opinion, that to say a transformer is *series wound* is somewhat unmeaning. All transformers known to me are wound alike, whether placed in series order or parallel order in the main supply conductors. The difference between a series transformer and a parallel transformer lies in the section and length of the wires, not in the winding. In a parallel transformer the primary wire is always longer and thinner than the secondary; the same may be the case in a series transformer, but oftener the reverse will be found to be the case. Series transformer or parallel transformer is better, or current transformer and potential transformer might do.

Electrical Measuring Instruments.

I have read with much pleasure Mr. Swinburne's excellent review of contemporary electrical measuring instruments, and with your kind permission should like to say a few words about instruments in which soft iron is used. I thoroughly endorse Mr. Swinburne's statement that the errors due to persistent magnetism are very troublesome—but they are by no means masters of the situation. Mr. Brunton and myself have carried out exhaustive experiments with all kinds, shapes, and descriptions of soft iron needles and pieces, and we find it possible to reduce the error arising from persistent magnetism to a negligible quantity The means we employ are—as might almost have been expected—simply, (1) reducing the mass; (2) laminating this very small piece of iron, which we find should not exceed 3 grains in weight; and (3), using as close and strong a field as possible.

Of course, the force directing the pointer is not enormous, but it is amply sufficient to direct a light aluminium pointer, pivoted in jewels, without error.

As to Mr. Swinburne's second mentioned source of error, what he happily calls "angular persistent magnetism." This error can be almost entirely avoided by placing the needle at the end of a short arm and making it of such a shape that magnetism at slightly different angles, does not make much difference to its total pull against gravity, by which we get our reading. For example, in my measuring instruments, the "needle" may be a round bit of iron foil at the end of the arm. The exact direction of the magnetic axis is unimportant. It does not sensibly affect the deflection.

J. G. Statter.

June 7th, 1887.